SCIENTIFIC AMERICAN
No. SUPPLEMENT 848

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Scientific American Supplement, Vol. XXXIII. No. 848.
Scientific American, established 1845.

NEW YORK, APRIL 2, 1892.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE CENTENARY OF SIR JOSHUA REYNOLDS.

SELDOM, if ever, in the history of art had so imposing and spontaneous a tribute been paid to genius as that witnessed in London on March 3, 1792. Spain and Belgium had doubtless displayed more taste and magnificence on the occasion of the burials of Velasquez and Rubens, for these were state ceremonials, in which the people had only the interest of spectators. But in the case of Reynolds every class seemed to recognize the loss the nation had sustained. "Never was a funeral of ceremony attended with so much sincere concern of all sorts of people," were Burke's words, writing to his son on the day following; and the sense of the nation's debt to the greatest painter of the eighteenth century has been steadily increasing since the day when, after a long illness, borne with cheerful fortitude, the Plympton schoolmaster's son passed away February 23, 1792, at his house in Leicester Fields. Fifty years had passed since he had first come to London to learn the rudiments of his art from Thomas Hudson, the principal portrait painter of the day, having just escaped being apprenticed to an apothecary.

Joshua Reynolds, born on July 16, 1723, was the seventh child of a family of eleven. His father, the Rev. Samuel Reynolds, was at that time master of the grammar school of Plympton Earl, a charmingly situated old town. Of the old school house where Samuel Reynolds taught, and his son Joshua spent a few years, nothing now remains but the colonnade, on the walls of which the latter left, in the shape of charcoal drawings, the first proofs of his love of art. According to the tradition, these drawings were done with burnt sticks, and the youthful Joshua was so little an adept that his works, which were considered less promising than those of his brothers and sisters, obtained for him the nickname of "The Clown." He was not, however, long in distancing his elder competitors, and we hear of his painting, at the age of twelve, his first picture in oils on a boat sail—a portrait of the Rev. Thomas Smart, a tutor in the family of Lord Edgcumbe—a picture which still exists and should form part of any complete exhibition of Reynolds' art. His father seems to have realized very soon the real bent of his son's talents, and, after taking counsel with one or two trusted friends, he determined to help the lad, who said "he would rather be an apothecary than an *ordinary* painter; but, if he could be bound to an eminent master, he should choose the latter." A few months later the momentous step was taken, and arrangements were made by which Hudson, also a Devonshire man, should receive young Reynolds into his house in Great Queen Street, and here the pupil took his lodging toward the close of 1740.

His stay with his master was prematurely brought to a close, ostensibly because Reynolds had delayed to take one of Hudson's pictures to Van Haaken, who was to paint in the drapery, but more probably because Hudson saw in his young pupil the rise of a fame which was speedily to eclipse his own, although it is only justice to Reynolds to say that throughout his career he acknowledged by word and act his indebtedness to his master. Reynolds returned to Devonshire, and at once set himself to earn a livelihood by painting portraits. The commissioner of Plymouth Dockyard at that time was Philip Vanbrugh, who seems from the first to have taken an interest in the youth. There is no means of ascertaining whether any relationship existed between Reynolds' early patron and the poet-architect, whose buildings were more dull than his plays; yet it is more than probable that the two artists met in later life, for Sir John Vanbrugh, who survived until 1776, was a member of the famous Kit-Cat Club, which Reynolds, at all events in his younger days, must have frequented. Reynolds' stay in Devonshire was not protracted; a sort of reconciliation with Hudson brought him back to London, and before the end of 1746 Reynolds had painted the portrait of Captain Hamilton, the father of the Marquis of Abercorn, the work which first brought him into notice. There is nothing in this picture which would arrest the attention of those who have seen Reynolds' later work, for it shows in a marked manner the constrained style of his master; but it was the means of obtaining for the artist a commission to paint his first portrait group, when, breaking with the traditions of all former art, Reynolds depicted Captain Hamilton carrying on his back one of the children of the first Lord Eliot. It was on this occasion that Reynolds painted his picture of a bewitching woman, Miss Chudleigh, then maid of honor to the Princess of Wales, who subsequently was only too well known as the Duchess of Kingston and a "professional beauty." His Devonshire friends continued to interest themselves in the young artist, and he was already beginning to make an income by portrait painting when he was again summoned back to Devonshire by the death of his father, and for the next few years made a home for his mother and sisters at Plymouth, where he went on painting portraits when he could get sitters, and in the intervals devoting himself to landscape work, for which the neighborhood afforded abundant scope.

PORTRAIT OF SIR JOSHUA REYNOLDS, BY HIMSELF.

It is not our object to follow Reynolds in his long, unbroken career of success, to which his manners contributed scarcely less than his talents. He won friends in all stations of life, and if he could be accused of paying too much court to the great and rich, it was to them that he had to look for patronage. There is, however, nothing to suggest any interested motives for his friendship with Commodore Keppel, to whom he owed the fortune of visiting Portugal, Spain, and Italy. He spent two years at Rome, and several months at other important cities, returning fully equipped as an artist, with a deeper sense of his own shortcomings than haunted any of his contemporaries, but inspired with a determination to fulfill as far as in him lay the prediction of his first instructor, Jonathan Richardson—that there were qualities in Englishmen which would shed luster upon the art of painting in a degree which would astonish the world.

In 1753 Reynolds' definitely fixed himself in London, first in apartments, at 104 St. Martin's Lane, where Sir James Thornhill, Van Host, the sculptor, and Hayman then lived, and afterward at 5 Great Newport Street. A few years later he made his final remove to Leicester Fields—or Leicester Square, as it is now called—then the artists' center, where Hogarth, Wilson, and Gainsborough had lived or were living. Reynolds' house was No. 47, and his painting rooms are now used as auction rooms, and are accessible to all. Little except the staircase and corridor remains of the old house, but some idea of the size of the studio can at least be ascertained. From the date of his first starting until a few months before his death he was never idle. His first pictures were painted at the rate of five guineas each; but now he raised the prices to twelve guineas for a head, twenty-four for a half length, and forty-eight for a full length portrait, and very shortly afterward he had advanced to fifteen guineas for a head, and the others in proportion. His industry was remarkable; his pocketbooks show that he painted from 120 to 150 in each year between 1755 and 1760, and there is no reason to suppose that he relaxed in his work until twenty or five-and-twenty years later. Yet scarcely a single work which belongs to this period shows the sign of slovenliness or haste. He managed to seize with unerring eye, and to transcribe with unfaltering hand, the distinctive grace of each sitter — man, woman, or child; he touched with grace each fleeting fashion, and by his art gave it permanency. The warrior, the statesman, and the scholar are depicted with that touch of genius which makes them live before our eyes, and at this distance of time enables us to understand their characters better than half the biographies of which they have been the subjects. His women are marked by a grace and a distinction which had been hitherto unperceived by the school of Lely and Kneller, as seen in the numerous portraits of the beautiful Duchess of Devonshire, the Ladies Waldegrave, Lady Charlotte Spencer, and the "beautiful Gunnings," to name only a few of his masterpieces. Even in the *race legere*, of which Kitty Fisher, Mrs. Robinson, Mrs. Abington, and, above all, Nelly O'Brien, were the examples, the indescribable smile, the seductive witchery, and varying tones denote the perfect artist, to whom mere sensuousness makes no appeal. It is, however, alone in his children that Reynolds appeals most widely, and, perhaps, even most permanently, to his fellow countrymen—"Simplicity," "The Age of Innocence," "Penelope Boothby," "Lesbia," "Miss Pelham Feeding Chickens," the "Strawberry Girl," are as familiar in our mouths as household words. Their simple charms never fail, their beauties are ever fresh, and we turn to them with national pride, not only as the works of our greatest artist, but as true types of English child life. It is here that Reynolds' claim to permanent fame is to be found. Living in an age of low ideals, of half-formed tastes, and of slightly varnished social life, he raised the standard of manhood, the beauties of womanhood, and the charms of childhood to a lofty pinnacle, and compelled his contemporaries and their descendants to live in view of this higher, nobler, purer life. He was

not intentionally, like Hogarth, a moralist on canvas; but by the strength of his genius he bade men and women see and feel that there was within them something which was not wholly frivolous, worldly, and perishable.

Of his interesting personality, his friend Edmund Burke may well say the last word: "His talents of every kind, his social virtues in all the relations of life, rendered him the center of a very great and unparalleled variety of agreeable societies. He had too much merit not to excite some jealousy, too much innocence to provoke any enmity. The loss of no man of his time can be felt with more sincere, general, and unmixed sorrow."

For the foregoing and our smaller illustrations we are indebted to the *Illustrated London News*, and for our larger portrait to the *Graphic*, London.

ILLUMINATING FLAMES.*

By Professor VIVIAN B. LEWES, F.I.C., F.C.S.

FLAME has always had an attraction for us which has been rivaled by few other natural phenomena; and whether we look back to the times when the old fire worshipers treated it as a deity, or take the present century and trace the work which has been done and the discussions which have been held as to its cause, and the actions which render it luminous or destroy its light-giving power, we are fain to admit that a subject which has drawn to it so much attention for upward of twenty centuries must be a worthy object for research, until such time as we have mastered every detail that bears upon the subject. It is upon flame that we have, up to the present, always depended for artificial illumination; and whether that flame has been derived from the torch, the rushlight, candle, oil lamp, or coal gas, it has played a part second to none in our domestic comfort; while with the birth and development of coal gas in the early years of this century, flame became an important commercial factor in the history of the country. It was not until the waning years of the last century that Lavoisier's historical researches upon combustion gave us the key to the action which leads to the formation of flame; and since that time its history has teemed with important researches, and still more important applications, which have to-day borne fruit in the improvements we see on every side in our methods of utilizing flame for both heating and illuminating purposes.

Flame, be it luminous or non-luminous, is produced by the combustion of gaseous matter; and a moment's consideration will render this clear to our minds. Take a piece of Wallsend or silkstone coal, and note how it burns on the hearth—first swelling and giving out tarry vapors, which ignite and form jets of flame; and these, encircling the coal, carry on the action, and give us the bright mass of flame which renders our English hearth so cheery a companion. On the other hand, take the coke which is derived from this same coal by its destructive distillation in the gas retort, and watch the clear coke fire as it burns. Here you have no flame of the kind given by the coal, but simply the glowing mass of fuel, with, at most, a small blue lambent flame playing over its surface.

What is it that has happened during the conversion of the coal into coke which made so great a difference in its method of combustion? If we analyze the coal and then the coke formed from it, we can at once trace the cause which has given us in the one case flame and in the other none:

	Silkstone Coal.	Coke from Silkstone Coal.
Carbon	79·0	89·0
Hydrogen	5·2	1·0
Nitrogen	1·5	1·0
Sulphur	1·5	1·2
Moisture	4·0	1·2
Ash	2·8	5·2
Oxygen	6·0	1·4
	100·0	100·0

The conversion of the coal into coke has been accompanied by the elimination of hydrogen, which, partly free and partly in combination with carbon, has been driven off, and has formed the coal gas; and with the destruction of the constituents capable of forming gas, the property of burning with flame has disappeared. Again, take a piece of pine wood, and ignite it. Its combustion will be marked by a large and luminous flame; while after conversion into charcoal, by elimination of its gas-producing constituents, it burns with a flameless combustion. From such experiments as these, we are forced to the conviction that flame is gas or vapor undergoing combustion; and inasmuch as combustion is chemical combination, we can define flame as being gaseous matter undergoing active chemical combination.

In all the earlier experiments with flame and with the other phenomena of combustion, it was only those substances which ordinarily burnt in air that were studied and experimented with—those bodies which would burn in air being called combustibles; while oxygen and air were looked upon as supporters of combustion. This conventional limitation of the processes of combustion still exists. A little reflection, however, shows us that such terms must be purely relative; as, if flame depends merely upon active chemical combination taking place between gases, it can only exist where both the combining gases are present, and it cannot matter which of them has the credit of being the combustible, as a jet of air or oxygen will burn just as well in an atmosphere of coal gas or hydrogen as the hydrogen or gas would in air.

It might be imagined that, having come to these conclusions with regard to flame, it would be a comparatively simple matter to solve the other problems connected with it; but, on studying the subject, it is at once found that the physical and chemical actions taking place are of the greatest complexity, and are in many cases governed by laws of which we know but little. In the propagation of flame, for instance, the combination of the inflammable constituents at the first moment of combustion gives rise to a great increase in temperature, which in many cases is sufficient to check and alter the combination, and in some instances even to cause dissociation of the products formed in the earlier phases of combustion; so that the combination seems to take place in waves, and not evenly, as one might at first imagine, with the result that the maximum temperature of a flame is never so great as one would expect from calculations based on the heat of combustion of the gases and the specific heat of the products and residual nitrogen from the air. These points, together with the rate of propagation and burning of gases, have been the subject of historical researches by Bunsen, Deville, Berthelot, and others; but much still remains to be done before we arrive at any final conclusion on the subject.

By far the most interesting, and at the same time important, chapter in the history of flame, however, is the consideration of the causes which lead to the luminosity of those flames upon which we depend for most of our domestic lighting; and these offer so beautiful a field for both physical and chemical research that they have attracted the attention of many observers, and form no inconsiderable addition to the chemical history of this century. In the year 1816, while engaged upon those celebrated researches which culminated in the discovery of the miner's safety lamp, Sir Humphry Davy noticed certain facts which led him to work out and propound his theory of the causes which lead to luminosity in flame—a theory which is generally stated as being that the presence of solid particles in the flame is essential to its luminosity. This theory remained unquestioned until 1808, when Professor E. Frankland, in his celebrated communication to the Royal Society, showed that, although incandescent solid matter in a flame renders it luminous, luminosity is also in many cases produced when the flame contains very dense vapors at a sufficiently high temperature, and also that a non-luminous flame may be rendered luminous by increasing the pressure.

This gave rise to a storm of criticism; and the next few years drew forth a rich crop of papers on the subject. Professor Frankland not only showed that flames might be luminous without containing solid particles, but advanced the theory that the luminosity in the flame of a burning gaseous hydrocarbon was due to dense hydrocarbon vapors, and pointed out that the soot deposited upon any cool substance held in such a flame contained hydrogen. To this W. Stein replied, showing that the deposited soot contained less than 1 per cent. of hydrogen, which was therefore probably only occluded by the carbon; and also that, if it had been present as a vapor in the flame, it ought, on being heated to the same temperature as the flame, to be once again volatile, which it undoubtedly is not. In the year 1874, Soret attempted to show that the cause of luminosity in flame really does depend upon the presence of solid particles, by focusing the sun's rays upon a luminous flame, and examining the reflected light by means of a Nicol prism; and rather later Burch pursued the same line of research, but employed the spectroscope for his examination of the reflected light. Their results point unmistakably to the presence of solid particles; and at the present time I think there is very little doubt in any one's mind that, as far as the flames of candles, oil, and gas are concerned, Sir Humphry Davy's theory is the correct one. Indeed, I am strongly of opinion that, although in certain points Davy went a little too far in his theory, had he been still among us we should have found that, in his own mind, he applied his theory more especially to the flames of our ordinary illuminants, as in his original memoir he speaks of "common flames," and distinctly says that "when in flames pure gaseous matter is burnt, the light is extremely feeble," and again, "the intensity of the light of flames depends *principally* upon the production and ignition of solid matter."

While this war of solid particles *versus* dense vapors was raging, Hilgard, Landolt, Blochmann, and Heumann were trying to trace the chemical actions taking place in various flames, and the causes which led to loss of luminosity when air was mixed with coal gas before combustion in the Bunsen burner. Heumann added the further proof to the "solid particle" theory of luminosity, that all flames which owe their luminosity to incandescent solid matter give definite shadows, while those in which luminosity is due to dense vapors give none; and that candle, oil, and gas flames all cause well defined shadows.

This brings the work done upon the cause of luminosity down to the present time. The accepted description of a luminous flame now is that it consists of several zones—an inner one, in which no combustion is taking place; a central one, in which, either by selective combustion or by direct decomposition by heat, carbon or very dense hydrocarbons are liberated, and, being heated to incandescence at the moment of production by the combustion of other gases present in the flame, give it luminosity; and an outer one, which consists of the products of combustion and atmospheric air heated to incandescence, and in which combustion is complete.

The work of Soret, Burch, and Heumann proves beyond doubt that our ordinary illuminating flames contain in the luminous zone particles of solid matter; and the only solid which could be present is carbon, either pure or containing the merest trace of hydrogen. The chief question now remaining to be solved, consequently, is the action taking place which leads to the formation of the solid particles in the luminous zone of the flame. During the last two years, I have devoted a very considerable amount of time and attention to the study of this subject; and I think I have found the key to this important problem—important from a practical point of view, because, until it is thoroughly solved, all efforts to improve our illuminating gases, and the burners in which we consume them, can only be the outcome of experiments made without definite idea of the means to employ in order to obtain the results we desire.

Coal gas is a mixture of hydrocarbons with hydrogen and small quantities of carbon monoxide; and it also contains traces of carbon dioxide, nitrogen and oxygen. The gas manager, however, does his utmost to eliminate the last three, which, if present in anything but the merest traces, would seriously injure the illuminating value of the gas. An analysis of the South Metropolitan Company's gas gives the following as its composition:

Hydrogen	57·08
Hydrocarbons—	
Unsaturated (containing 0·035 p. c. of acetylene)	4·38
Saturated	33·99
Carbon monoxide	2·63
Carbon dioxide	0·79
Nitrogen	0·96
Oxygen	0·15
Bisulphide of carbon	0·02
	100·00

The unsaturated hydrocarbons consist of ethylene, benzene, propylene, butyiene, and acetylene, and probably also traces of crotonylene and others; while the saturated hydrocarbons consist chiefly of methane, with traces of ethane, propane, and butane.

Analyses made by Landolt of gases withdrawn from various parts of a luminous coal gas flame, and also a long series of analyses which I have made, show that, as the gas leaves the burner, the hydrogen is the first to be consumed; and that, in the passage up the non-luminous part of the flame, the carbon monoxide largely increases in quantity, while at the same time the methane rapidly decreases, and the unsaturated hydrocarbons seem to be the least affected. In the luminous zone the unsaturated hydrocarbons rapidly disappear; while the carbon monoxide formed in the inner zone, and also the residual hydrogen and methane, undergo combustion.

Prof. Smithells, in a paper read before the Chemical Society in December last, also proved that, during the incomplete combustion taking place in the inner cone of a Bunsen flame, this same increase in the amount of carbon monoxide was to be observed. The fact that the decrease in quantity of the unsaturated hydrocarbons was but slow in the inner zone, and then took place with considerable rapidity in the luminous zone, favored the theory that they were broken up by heat in that portion of the flame, and liberated the carbon, which by its incandescence gave the luminosity. But it does not seem to have occurred to any one to try to determine whether the unsaturated hydrocarbons at the top of the non-luminous zone were of the same description as those in the coal gas.

It is a matter of common observation that the checked combustion of a luminous flame at once gives rise to the escape of acetylene, and also that, if a Bunsen burner catches light at the bottom, large quantities of acetylene are formed, of which the presence is at once detected by its distinctive and pungent odor. These facts suggested the idea that, in the inner cone of the flame, acetylene might be formed by decomposition of the original hydrocarbons; and experiment at once showed this to be the case. Of the unsaturated hydrocarbons present in coal gas, 0·8 per cent. consist of acetylene; while, at the top of the non-luminous zone of a flat flame produced from the same gas, between 80 and 90 per cent. of unsaturated hydrocarbons present consist of acetylene; and in all the other luminous flames experimented with the same action was found to take place.

On taking the most important hydrocarbons present in the coal gas, mixing them with about 20 per cent. of air, and passing them through a tube heated to the temperature existing near the top of the inner non-luminous zone, the following results were obtained: Methane gave rise to unsaturated hydrocarbons, acetylene, and carbon monoxide; ethylene gave acetylene and carbon monoxide; hydrogen charged with benzene vapor gave the same; and ethane gave unsaturated hydrocarbons, acetylene, and carbon monoxide. These experiments clearly show that, in the inner non-luminous zone of the flame, the heat generated by combustion of the hydrogen of the coal gas, in the presence of the small proportion of air drawn into the flame at this point, causes the conversion of the hydrocarbons present in the gas into acetylene and carbon monoxide.

Acetylene is a clear colorless gas, with a strong and disagreeable odor. It consists of 24 parts by weight of carbon, combined with 2 parts by weight of hydrogen. It is one of those bodies which, during their formation, take in heat instead of giving it out; and it is therefore called an "endothermic" compound. Such substances are especially liable to decomposition, as this is accompanied by a rise in temperature instead of, as is the case with most decompositions, an absorption of heat. Acetylene is decomposed at a bright red heat into carbon and hydrogen, together with traces of tarry matter as well as ethylene; while Berthelot has shown it to be so unstable that it can be broken up into carbon and hydrogen by detonating a percussion cap in it.

These important points being established, it is necessary to ascertain if the temperature existing in the various parts of a flame give any clew to the actions going on within them. The beautiful platinum and platinum-rhodium thermo-couple devised by M. Le Chatelier, and introduced to us by Mr. W. Chandler Roberts-Austen, gives a means of measuring the temperatures of flames with an ease and comparative accuracy which was never before hoped for. I made a small thermo-couple of platinum and 10 per cent. of rhodium, platinum wire, using it as thin as possible to reduce errors from loss of heat by conduction, and keeping the wires of considerable length to prevent any chance of rise of temperature introducing conflicting currents at the connections with the galvanometer wires. A reflecting galvanometer was employed, and sufficient resistance was introduced into the circuit to keep the spot of light upon the scale at the highest temperature of the flame; and the scale was then graduated for temperature by taking water at 0° and 100° C., and checking the higher temperature by the fusing points of the chlorides of the alkalies and alkaline earths, as determined by Dr. Carnelly.

With this arrangement I was able to map out the temperatures existing in the flat flame in which I had traced out the changes taking place in the constituents of the gas; and I found that the temperature rapidly rose from 500° C., half an inch above the burner, to a little over 1,200° C., at the commencement of the luminous zone—the luminous edges having a temperature of 1,216° C.; and these temperatures were further increased in the luminous zone until, near the top of the flame, 1,368° C. was reached. This at once gives us the secret of the luminosity. From the mouth of the jet and up

* A recent lecture before the London Institution.

to a temperature of 1,000° to 1,200° C., we have the formation of acetylene from the original hydrocarbons; but the moment the requisite temperature is reached by the combustion of the hydrogen and the carbon monoxide, the acetylene decomposes, with a further rise of temperature, and the carbon heated to incandescence radiates heat and light.

If a luminous flame be cooled, its luminosity is at once diminished, and may be destroyed; while, as the propagation of flame requires a certain temperature, a further cooling will extinguish it. In the outer edge of a flame, the rapid inrush of air sucked into the flame so lowers the temperature that a thin envelope is rendered non-luminous, the actions checked, and traces of the

SIR JOSHUA REYNOLDS.

Born July 16, 1723. Died February 23, 1792.

gas allowed to escape unconsumed by the extinction of the extreme limit of the flame; and delicate analysis shows that every luminous flame burning freely in air gives off distinct traces of carbon monoxide, acetylene, and even such highly inflammable gases as methane and hydrogen.

Ever since the structure of flame has been noted and discussed, it has been accepted as a fact beyond dispute that the outer, almost invisible, zone which is interposed between the air and the luminous zone of the flame is the area of complete combustion, and that here the unburnt remnants of the flame gases, meeting the air, freely take up oxygen, and are converted into the comparatively harmless products of combustion, carbon dioxide and water vapor, which only need partial removal by any haphazard process of ventilation to keep the air of a room fit to support animal life. The facts I have brought before you show that this is not the case; and they fully explain why gas is so oppressive in a badly ventilated apartment.

It has always been the custom to speak of flame as built up of zones; and although there are no sharp lines of demarkation, in the actions taking place, which would warrant this, still three distinct portions are

SIR JOSHUA REYNOLDS' HOUSE IN LEICESTER SQUARE.

visible to the eye. If we divide the luminous flame into zones, it would be perhaps best looked upon as consisting of three, viz.:

(1) The inner zone, in which the temperature rises from a comparatively low point at the mouth of the burner to about 1,000° C., at the apex of the zone. In this portion of the flame, the constituents of the gas undergo various decompositions and interactions, which culminate in the conversion of the heavier hydrocarbons into acetylene—carbon monoxide being also produced; and these, with the products of combustion and residual hydrogen, pass into the next phase of action.

(2) The luminous zone, in which the temperature ranges from 1,000° C. up to a little over 1,300° C. Here the acetylene formed in the inner zone becomes decomposed by heat, with liberation of carbon, which at the moment of production is heated to incandescence by the combustion of the carbon monoxide and hydrogen, and gives luminosity to the flame.

(3) The extreme outer zone, in which, combustion being nearly completed, the cooling and diluting influence of the entering air renders a thin layer of the flame non-luminous, and finally extinguishes it. With ordinary coal gas, this results in the escape of traces of hydrogen, methane, carbon monoxide, and acetylene; while with a very rich gas unconsumed carbon also escapes.

This description of a luminous flame is of necessity far from complete, as it leaves out of consideration the interactions which lead to the formation of acetylene, and also the decompositions going on in the various parts of the flame between the products of combustion and the flame gases; but I think it marks a considerable advance in our knowledge of the main actions which lead to luminosity—the other interactions being at best subsidiary to it.

Having obtained a clear idea of the causes which lead to luminosity in flame, we are enabled for the first time to clearly understand the actions taking place in the atmospheric or Bunsen burner, the invention of which revolutionized our methods of heating by gas, and made coal gas one of the most important of our domestic fuels.

When it was first found that the admixture of a certain proportion of air with coal gas before combustion caused it to burn with a non-luminous flame, it was at once accepted, as an explanation of the phenomenon, that the extra oxygen so led into the inner cone of the flame, by causing complete combustion in the central zone, burnt up the carbon before it could be heated to incandescence, and so destroyed its light-giving power. Some years later, however, Knapp and others showed that, by mingling inert diluents, such as nitrogen, carbon dioxide, or even steam, with the gas before combustion, non-luminosity could be produced. It was then recognized that the diluting and cooling action of the nitrogen in air played an important part; and some observers held that it was this, and not the oxygen, which was the cause of non-luminosity.

On measuring the amount of air and of nitrogen respectively able to render a Bunsen flame non-luminous, they are found to be practically the same, while the quantity of oxygen present in the air used, when passed into the gas by itself, still gives a very luminous flame. This certainly looks as if it were the nitrogen that was doing the work. If this were so, the temperature of the flame rendered non-luminous by nitrogen should be the same as that of the flame rendered non-luminous by air; but, on testing these, the fallacy of such a supposition is at once exposed. This will be seen by the following table:

Part of Flame.	Temperatures existing in a Bunsen Flame rendered Non-Luminous by— Nitrogen.	Air.
¼ inch above burner.....	30° C.	54° C.
1¼ inches above burner...	111°	175°
Tip of inner cone.....	444°	1,090°
Center of inner cone.....	999°	1,533°
Tip of outer cone.....	1,151°	1,175°

These temperatures clearly show that a very considerable amount of combustion is due to the oxygen of the air, and make it perfectly manifest that both the oxygen and the nitrogen are acting in bringing about the loss of luminosity.

While working at these points, I found that if mixtures of nitrogen and oxygen, poorer in oxygen than air, were employed, it was practically only the nitrogen which acted—the diluting effect being so strong that the oxygen was prevented from taking any active part. With air, both act; while with mixtures richer in oxygen than air, the oxygen alone acts—the nitrogen being apparently unable to exercise any retarding influence. The same result is obtained if excess of air is mixed with the gas before combustion. If the quantity of air reaches a point at which the proportion of oxygen in the air is to the gas as 0·5 : 1, then the diluting influence of the nitrogen is lost, and the appearance of the flame becomes entirely altered. The normal Bunsen flame burns with a lilac-colored inner and blue outer zone; but the moment the quantity of air admitted reaches the ratio mentioned, the flame becomes short and fierce, and the inner zone changes to a greenish color—the highest temperature in the flame at the same time increasing by nearly 100° C. Experiments show that the nitrogen acts in the normal Bunsen flame by so diluting and protecting the hydrocarbons that a far higher temperature is needed for their decomposition; and this action gives time for the oxygen of the air to consume them without liberation of carbon, and hence without luminosity.

In conclusion, I think that we may express the actions which lead to the loss of luminosity in the normal Bunsen flame in the following way:

(1) The chemical activity of the oxygen introduced in the air, which, by burning up the molecules of hydrocarbons before, in their diluted condition, they undergo decomposition, causes loss of luminosity.

LORD HENRY AND LADY CHARLOTTE SPENCER.

(Picture by Sir Joshua Reynolds.)

(2) The diluting action of the nitrogen of the air, which, by increasing the temperature necessary to bring about the partial decomposition of the hydrocarbons, prevents formation of acetylene, and in this way will, by itself, cause non-luminosity; and in the normal Bunsen flame it acts by doing this until destruction of the hydrocarbons by oxidation has taken place.

(3) The cooling influence of the air introduced, which is able to add to the general result, although the cooling is less than the increase in temperature brought about by the oxidation due to the oxygen in the air.

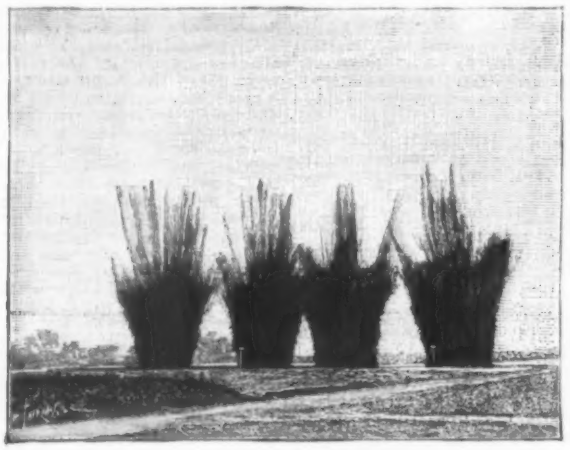
NICKEL PLATING.

THE following process of nickel plating trailing wheel parts and similar articles is said to give excellent results. The bath is composed of 1,000 grammes of pure nickel sulphate, 750 grammes of neutral tartaric acid ammonia, 5 grammes of gallic acid (tannin), and 20 liters of water. The neutral tartaric acid ammonia is obtained by saturation of a solution of tartaric acid with ammonia. The nickel salt must be neutral. For this purpose the whole is dissolved in 3–4 liters of water, and allowed to boil for about ¼ of an hour. Then as much water is added as will produce altogether 20 liters of fluid, which is filtered. The precipitate obtained is very white, soft, and uniform, and bears no traces of roughness on the surface. On crude or polished castings very heavy deposits can be obtained, and at a price which scarcely exceeds that of copper plating. Galvanoplastic impressions may also be obtained in this bath. The current need only be weak.

EXPLOSION OF DRY TORPEDOES.

INSTANTANEOUS photographs representing the firing of a gun are familiar subjects. These photographs give the attitude of the artillerymen and the aspect of the smoke, in many cases, with the grains of powder still burning in the air, after being blown out of the gun. We now present our readers with a still more curious document. It concerns a photograph taken during the explosion of some dry torpedoes planted in the earth. The negative was taken by Mr. Alexandre, a skillful operator of Brussels.

The following is what our correspondent says on the subject: "Annually attending the grand maneuvers of Belgium, I this year had an opportunity of taking the accompanying photograph. The engineers having established some mine chambers in front of a large redoubt, and I, having been notified by the commandant, was enabled to obtain a satisfactory negative, as regards sharpness, although my apparatus was considerably shaken by the effect of the explosion. The photograph was obtained upon a Lumiere plate. The objective was provided with a Thury & Amey shutter regulated to a 300th of a second. I stood at a distance of about three hundred yards from the place of explosion, in a good light."



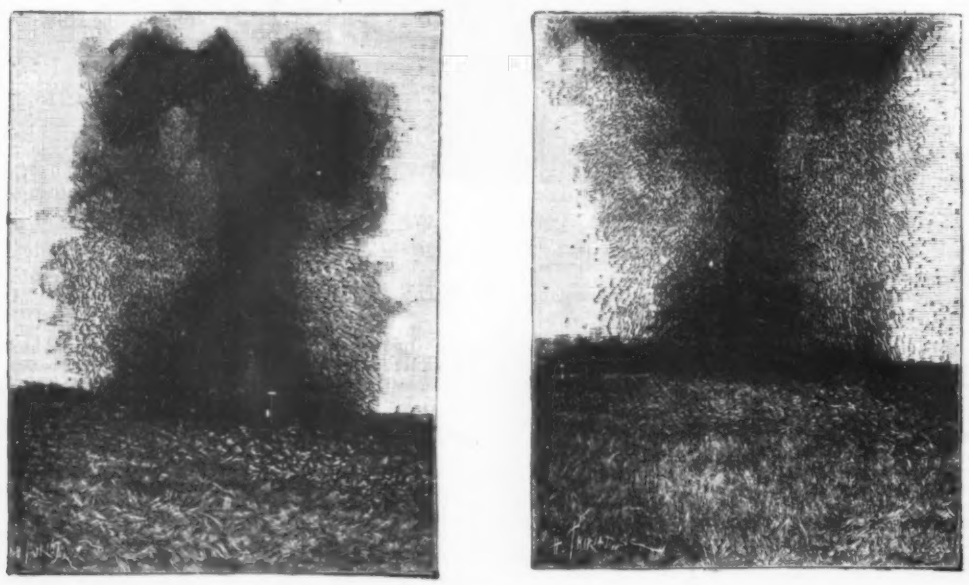
EXPLOSION OF DRY TORPEDOES.

(From an instantaneous photograph.)

We believe that this is the first time that a photograph of this kind has been obtained. One may, from the mass of earth thrown up, judge of the intensity of the effects produced by the subterranean torpedoes and of the efficiency of their action for the defense of frontiers or the vicinity of forts. We have, however, already given detailed articles on the nature and method of using these explosive apparatus, and need not return to the subject. The photograph that we reproduce completes the data that we have already published upon dry torpedoes and military mines.

On this subject we have received an interesting communication from a skillful amateur photographer, Mr. Emile Christiaen, who writes us from Passchendaele-lez-Roulers (Belgium), as follows:

"I have read with much interest your article upon the explosion of dry torpedoes. I take the liberty of sending you two of my photographs of these same torpedoes that I took, like Mr. Alexandre, of Brussels, at the time of the grand maneuvers that took place here in our commune of Passchendaele. These photographs were taken my means of a Steinheil antiplanat and a shutter adjusted to 150th of a second, at a distance of about eighty yards, in beautiful weather. The first photograph (Fig. 1) was taken at the moment of the explosion, while the upheaved earth was in its ascensional flight. The second (Fig. 2) represents a second explosion, while the upheaved earth is beginning its fall."



FIGS. 1 AND 2.—TWO PHASES OF THE EXPLOSION OF A DRY TORPEDO.

We congratulate our correspondent on the interesting results that he obtained. The beautiful photographs that we reproduce herewith form a complement to those that we have heretofore given. These are original documents, the like of which, as far as we know, have never before been published.—*La Nature.*

THE BLEACHING OF COTTON.

BLEACHING is a very different process from that employed some decades ago, when chemists were endeavoring to discover some system better adapted than exposure to the open air of a bleach ground. The introduction of bleaching powder paved the way for the present effective methods. This powder, which is now well known to be one of the most common and important chemical elements—chlorine, in combination with sodium—gives common salt (chloride of sodium), one of the most plentiful and widespread substances in nature. A great economy of time and labor was effected by its use, and, in one form or another, it is still a reliable agent in bleaching cotton material. Raw cotton imbibes a certain amount of grease and dirt, which is added to by the process it undergoes, up to the spinning of it into yarns and the final consummation into cloth. It is, therefore, of the utmost importance to remove these impurities, especially the grease, before the actual bleaching operations take place. We cannot afford space for the many treatments—so-called improvements—experiments, etc., which have obtained from time to time, and vanished as quickly as they came, but we will give information from the best sources of methods which are not only satisfactory and economical, but are likely to retain a precedence, and, therefore, to make the process of bleaching as complete in description as possible, without any after reference. We will state the best methods for the treatment of yarns and woven cloths. The mere dirt is easily removed by washing—this is the first step, but grease, oil, and other stains are not easily removed. The simplest way, in cases of this kind, is to boil the material in lime water or any alkali, such as potash, soda, or ammonia. The soap which is thus formed can be easily separated, and the material is quite ready for bleaching. Of course, repeated washings for extreme cases of soiled or stained goods will be necessary, as well as, between each washing, a thorough rinsing in pure water. The water purification is of the greatest importance, and the more rinsings the materials undergo, the greater the economy in time and labor in the further operations. The next process may be bringing the goods under the influence of chlorine as a gas or dissolved in water, or using the chlorine in combination with calcium, the metallic base of lime, lime being its oxide. By the use of the gas, the operation is at once effective and rapid, but it entails the risk of burning the fiber, or what is known as "rotting" the goods. By the combination with calcium, there is less risk, because it can be regulated at will, if the strength of the chloride lime solution and the temperature and time employed are properly adjusted. The coloring matter being the first point of resistance, when this has been sufficiently operated upon, the materials ought to be removed at once. The quality, quantity, and character of the goods must determine the strength of the bath. This requires experience and good, sound judgment. The chloride of lime is generally absorbed by the material in the bath in something like a period of six hours, then passed into a very weak bath of sulphuric acid, which combines with the calcium, leaving the chlorine a free agent to act upon the coloring matter. A steeping for a day or night removes the sulphate, and the decomposed coloring matter is boiled out by carbonate of soda. To obviate any trace of yellow tinge, the material is generally passed through a weak acid bath, and the boiling with caustic or soda carbonate may require a day or, perhaps, only eight hours, according to circumstances and quantity. The whole process does not exceed two days. If the goods are to be dyed or printed, it would be prudent to allow more time rather than use stronger solutions, as the colors are, to a certain extent, impoverished in brilliancy by undue haste. These details are general. Different well known bleaching establishments vary their processes according to the class of goods in hand. The details followed by one of the largest firms will be found not only useful but exhaustive. The improved keir much used at the present time consists of a steam-tight vessel of a cylindrical shape, made of cast iron, heated by steam at a low pressure. The goods are placed on a grating, and a vertical pipe, with a cap at its upper opening, causes a distribution of the lime liquor. An iron pipe, in connection with the keir below the grating, has two branches, each possessing a valve, one supplying water, the other steam. The mouth of the keir is flanged, so that the cover can be bolted down and thus made steam tight. One ton and a half of goods can be operated on, the process occupying from ten to fifteen hours. For this weight of material, 2 cwt. of lime, previously dissolved in water, and used as milk of lime, is necessary. This is poured upon the goods as they enter the keir, and a quantity of water added to cover the material. The high pressure steam process is also used, and is said to be more energetic, and the goods have a more complete impregnation of the liquor, but constant attention is required, and, to insure success in the management of the keirs, they can only be intrusted to the care of a very competent operative. No such extra care is needed in the low pressure treatment. Souring or washing consists in passing the goods through a weak solution of hydrochloric acid, and then through water, to remove lime and insoluble lime soap, together with any metallic oxides that may be attached to the fibers. A few hours' steeping allows the acid to thoroughly decompose all impurities. The soda ash process is performed in the same keir as described. A certain quantity of resin soap, along with the soda ash, is placed at the bottom of the keir, and is soon dissolved by the water, about 1·5 cwt. of soda ash and 80 lb. of resin soap being allowed for 1·5 tons of cloth. By this boiling, all fatty acids are converted into soluble soda soaps, which are easily removed by washing. The cloth, having passed these operations, is cleansed from nearly all impurities, but is wanting in the requisite whiteness. To destroy the least trace of coloring matter, the pieces are passed through a very dilute solution of bleaching powder at specific gravity 1·0025, or one-half degree Twaddell, till completely saturated with the liquor, then passed through squeezing rollers, to remove the excess of solution, and afterward allowed to lie for some hours. This process is commonly known as "chemicking." The bleaching powder is a mixture of hypochlorite and chloride of calcium. The second passing of the goods is through a weak acid bath—sulphuric acid, gravity 1·075, or, as before alluded to, 1·5° Twaddell. The final operations are washing and drying, this last being performed by passing the pieces, opened out to their full extent, over and under a series of hollow iron or copper cylinders, heated by steam, the greater portion of the water being previously removed by squeezers. Cotton yarns are bleached by the same process as cloth—the skeins being first boiled in water, then in a weak solution of bleaching powder, then again in weak acid, and finally washed and dried. Sulphuric acid is not equal in action as a lime scour to hydrochloric acid, which is very soluble, and is thoroughly removed from the goods by washing. The sulphuric acid forms with lime insoluble sulphate of calcium, which is very difficult to remove entirely. In all cases the acid should be of a uniform strength to give satisfactory results. The Twaddell test is no guide of the strength, as the lime dissolved by the acid raises the Twaddell, having reduced the strength of the acid. The following test is best, and most easily carried out: Take a solution of caustic soda, known as 77% Newcastle (this make of soda to be always used as a standard at a strength of 20° Twaddell); then a narrow, tall white glass bottle, with a mark at the top, may be filled with this solution. A five ounce measure of freshly prepared souring liquor, at 2° Tw., is poured into a jar, and some of the soda solution carefully added to it, until a portion of cloth dyed with turmeric is turned brown when dipped in; this shows that the acid is neutral, and the quantity below the mark on the bottle determines how much has been required. In every test of the liquor, five ounces must always take the same quantity of the test solution—if less, it is too weak; if more, too strong. The bottle would be better graduated 1°, 2°, etc., and also for 2° of Tw. Many bleachers use caustic soda instead of soda ash: 120 lb. of caustic soda will suffice for five tons of cloth. The details which we have given are simple, and the different operations are the most perfect kind of bleach at present applied to cotton cloths. It is known as the madder bleach. The turkey red bleach is identical, so far as the operations are concerned, with those already described, and so is the market bleach, but every bleacher differs more or less in a few details, but the principles upon which the whole process depends remain, so far, unchanged. Water, in some instances, may be hard, requiring more acid, alkali, and resin; the steam pressure will vary, and the strength of an alkali will cause a difference in quantity. On these points, it is impossible to give general rules, the nature of the conditions being so variable. We can only afford a brief glance at a few new systems now engaging the attention of bleachers and manufacturers. It is remarkable how the same operations are rediscovered over and over, and old

specifications of patents are rehearsed. Caustic soda for cotton was patented forty years ago, and we could give scores of instances, in every branch of the textile industries, where something new, oftener than not, turns out to be as "old as the hills." The bleaching of cotton by hydrogen peroxide, or in other words, a highly inflammable gas, with a powerful oxide, containing the greatest possible quantity of oxygen, is supposed to be the most efficient of all agents. We are told that its superiority cannot be explained so far, but it is advisable, prior to using this dangerous compound, to treat the cotton with a weak acid, in order to remove the metallic salts and oxides from the raw tissue. We have already shown that this is done by the ordinary process of bleaching, and further details give the following profound summing up: "Bleaching cotton with hydrogen peroxide, the latter acts upon the cellulose, carbonic acid being always formed, the fatty bodies, remaining upon the fiber, as oleates, palmitates, etc., of magnesia, with an after treatment of alkaline lye." Very little information for practical purposes is conveyed in these statements, which are vague, and almost unintelligible. The process may be suitable for wool. Bleaching by electricity and with a new bleaching powder called "fluor acid" may be passed over, as no satisfactory developed results, economical and really practicable on a large scale, have been obtained. We may more pertinently end our remarks by giving a useful receipt for the bleaching of samples, such as a few hanks, short pattern warps, etc., that are required quickly and with brief notice. Boil the twist well in water, with two ounces of soda ash to the gallon, and mix one pound of chloride of lime, fresh, in two pints of water, crushing all the lumps; add 43 pints more of water, allowing time for lime to settle; pour off the clear liquor and immerse the yarn for ten hours, in a cool place; keep from contact with iron. Wring out, and wash in cold water; the yarn must not remain in the air too long. Then steep in a well mixed solution of 26 drachms of double oil of vitriol to 45 pints of water. The yarn must remain in this acid solution ten hours, or during the night; wring out, wash off in cold water. In order to thoroughly remove the acid, work well in a good white soap bath, and add a little marine blue to give the yarn any desired tint. Finally, wash in warm water to clear out the soap. These proportions will do the least injury to the fiber strength. If time is to be shorter, a stronger solution can be used. Soft mule yarns the solution one-third weaker, but for double yarns, the strength must be increased according to perfection required in whiteness.—*Textile Industries.*

INCUBATOR REGULATORS.

J. A. BUFFER, writing to the *English Mechanic*, says: Probably more attention has been paid to the subject of artificial incubation in the United States during the last fifteen years than elsewhere. During that period upward of 500 patents have been granted for incubators and their attachments.

The heat of incubators is usually controlled by one or more of the following methods: The opening of a valve to allow the hot air to escape; to allow the heat of the flame to escape; by reducing the flame. This last method is usually accomplished (assuming the heat to be produced by a coal oil lamp) by cutting off the air supply from the flame; this is done by a collar, which fits loosely around the wick tube, and when down is level with the top. It is lifted by means of a crank or lever; ⅛ inch rise of the collar reduces the flame more than one-half. Similar results are attained by the use of a burner such as is usually sold with hanging parlor lamps. By simply pulling a small chain, two jaws are brought together above the flame, and the light is extinguished or reduced, according to the length of the pull.

The use of any mechanism to reduce the flame has two objections. First, it requires to be disconnected from the other attachments every time the wick is trimmed. To avoid this, wicks of asbestos, being fireproof and claiming to require no trimming, have been tried; but the oil soon clogged the pores, and sufficient oil could not be supplied to the flame. The other objection is that there is a bare possibility of a few grains of charred wick dropping between the tube and collar, causing it to bind, and the flame continuing to burn overheats and destroys the eggs. The only advantage in reducing the flame is the saving of about one gallon of oil during a hatching. Are we warranted in risking an incubator full of valuable eggs for this saving? Certainly not; and the best incubators of this country are no longer regulated by this means.

I was surprised to see in a late issue of the "E. M." an article illustrating an incubator, in which the lamp wick was turned up or down by a gearing, so regulating the flame. Why resort to such a crude and ancient method when either of the above methods could be used, and requiring only one-fiftieth of the power to effect a like result?

Among the various methods employed to regulate incubators, I recall the following: A curved strip of brass, the heat expanding it and completing an electric circuit. A compound bar of brass and steel, riveted together either straight or in spiral form. The expansion of mercury in a glass tube closing an electric circuit. A system of compound levers made of compound bars, affecting a weight and clockwork mechanism. A rod of hard India rubber or gutta percha, similarly operated, which, unlike most other materials, contracts by heat. A capsule of metal, charged with a few drops of ether, carbon bisulphide, chloroform, alcohol, or other like substance. This form of regulator is used on Hearson's incubator, as recommended by Mr. Fraser. It is also used in this country, but three or more capsules are usually connected.

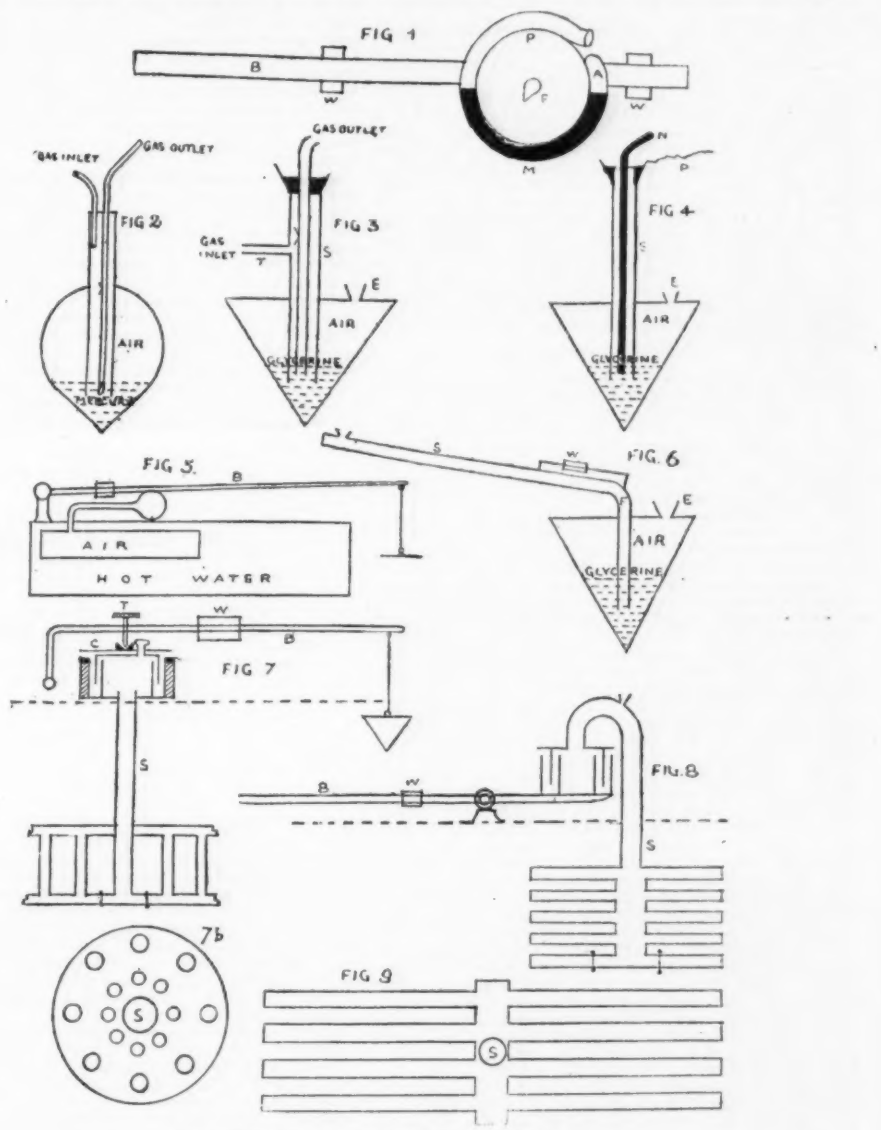
Some years ago I made over 100 capsules of different sheet metals, and used various substances to create expansion, and I found all the capsules unreliable, and not near so effective, sensitive, and certain as my latest regulator described further on. With capsules, the first expansion stretches or draws the metal, which never regains its former condition.

I inclose herewith a sheet of drawings of regulators which may be of interest to the many readers of the "E. M.," and will proceed to describe them.

Fig. 1. This is a balanced rod, and works by the expansion of alcohol and mercury; P is a grooved wooden pulley about 6 in. in diameter; in the groove a glass tube of ¼ in. bore, and closed at one end, is bent and securely strapped in place as shown; F is a knife-edge bearing; B is a rod attached to the pulley; W are weights to balance the regulator; in the tube a quantity of alcohol is placed, as shown at A. Mercury is then poured in as shown; the expansion of the alcohol and mercury tip the beam. This regulator is patented in the United States. Its objections are: 1. Being made of glass, it is easily broken. 2. All adjustments must be made inside of the incubator. 3. The quantity of mercury necessary.

Fig. 2 is a regulator working by gas; it is quite common here, and an improvement on the crude affair described by a correspondent in the "E. M." four or five numbers back. It is made of glass. The drawing explains itself. In the gas outlet tube at V a hole is drilled sufficiently large to allow just sufficient gas to pass to keep the flame lit when the gas is shut off by the mercury, thus dispensing with the necessity of a second tube and jet of gas to the main burner.

Fig. 3, as my improvement on Fig. 2, is made entirely of metal, is not liable to be broken, and is also much more sensitive to heat and cold than glass. Furthermore, the stems S, G, and E can be made long enough to extend up and through the incubator or other heating arrangement. The air chamber is a cone 6 in. in diameter and 5 in. or 6 in. high, made of thin sheet tin plate or brass. The tube S is of brass, with an elbow



INCUBATOR REGULATORS.

E, and the air chamber are the same as Figs. 3 and 4; the stem *s* is bent and closed at the end, with the exception of a small hole *v*, to allow the air to escape should it expand in the tube. F is a knife-edge bearing; W is a weight sliding on a wire rod soldered to the tube S. The play of the upper end of this tube should be limited, so as to keep it always on an incline. This allows the glycerine to flow back to its place. In operation, the glycerine is forced up and along the tube S, tipping it and giving the movement, Fig. 7. This regulator is also of my own design, and, I think, is the best, simplest and most sensitive regulator ever invented. When properly made and adjusted, it will maintain a given temperature with a variation of not more than one-half of a degree. The air chamber is composed of two thin sheet tin plates or brass capsules about 9 in. in diameter, the edges of each plate being turned up ⅛ in., one fitting within the other, and soldered at the edges. These two capsules are connected by a number of 1 in. sheet brass or tin plate pipes 4 in. or 5 in. long. The arrangement of the pipes and the punching of the two inside plates of both capsules is shown in Fig. 7 B. The object of making it this way is to expose a given amount of air to the largest possible heating and cooling surfaces. Through the lower capsule three or four rivets are soldered, which prevent the lower plate from bulging down by the expansion of the air within. S is the stem which rises through to the top of the incubator. To this a cup, 6 in. diameter and 3 in. high, is soldered. Inside of this cup a ring 4 in. high is soldered, leaving an inch space all around, which is filled to within ½ in. of the top with cotton or wool. On top of this plaster of Paris is poured and smoothed level with the top ring. Another ring, 3 in. in diameter and 3 in. high, is then soldered within the cup, which leaves a center space of 3 in., into which the stem S extends, ½ in. being soldered thereto. Outside of the 3 in. ring there will then be an annular space of ½ in., which is nearly filled with glycerine, into which the cup *c* dips, and is sealed. To T, a disk 6 in. in diameter, is soldered a collar 3 in. high and 3⅛ in. in diameter. This is the inverted cup *c* shown in the figure. Inside of this cup 1 in. of cotton is packed, against which a disk of tin is soldered. This and the other filling is inteuded to prevent the external air from cooling the heated air within. Through the top of the cup is soldered a small tube, to which is soldered a small screw tap, such as is used on perfumery bottles; it must be screwed on air tight; it acts as a vent to put the cup in place. In the center of the top of the cup is soldered a small piece of brass, having a conical recess into which the conical point of the thumb screw T sets. The rod B, bent as shown, is of ¾ in. square wrought iron, which gives weight and steadiness. The bearing is the same as used on telegraph instruments. The weight W is a piece of lead bent to fit the rod, and slides back and forth to balance the air pressure. In operation the air expands, forces up the cup, which lifts the rod B.

Fig. 8. This is another form of my regulator. The

Fig. 4 is an electrical regulator of my own design. *s*, *e*, and the air chamber are the same as Fig. 3; N is a piece of gutta percha-covered wire, slipping tightly through a hole in a cork, which fits in *s*. The cold glycerine is loaded with as much salammoniac or common salt as it will dissolve. This makes it a good conductor, one pole of the battery being attached to any part of the regulator, the other to the insulated wire N. In operation, the heat expands the air, forces the glycerine up the stem S, until it touches the exposed end of the wire, which completes the circuit.

Fig. 5 is an air cylinder surrounded by hot water, heated by a lamp. From the air cylinder a tube rises to the top of the incubator, and to its end is attached a hollow rubber ball, upon which a weighted lever rests. The expansion of the air in the cylinder is supposed to expand the ball and lift the lever. The arrangement is patented in the United States. I do not think it is reliable, or that it would work well for any length of time, owing to the effect of heat and cold on the rubber.

Fig. 6 is a balanced regulator of my own design. S, at T. The tube *g* slips through a cork, which fits in the tube S, and, when adjusted, is sealed up with sealing wax or gasfitter's cement. At E is a small opening in which a small rubber cork or tight-fitting screw cap fits. The opening is used to drop in a few drops of ether, in case rarefied air does not give sufficient pressure. The operation is the same as Fig. 2. In all regulators where gas is used, to obtain good results, it must be of a uniform pressure, necessitating a reliable governor at the meter.

air chamber consists of a number of capsules 9 in. in diameter, and ⅛ in. high, soldered together as shown, the knife-edge bearing stem S, vent V. Glycerine seal and other parts will be readily understood by the drawing.

Fig. 9 is another form of air chamber which occupies very little space above the eggs. It is made entirely of thin sheet tin plate or brass; the center is a box of 1½ in. square by 6 in. long. On the two sides are punched four 1 in. holes. Into these tubes are soldered, the outer ends of which are capped, or otherwise securely closed. These should be as long as the incubator space admits of. In the center of the top of the box is a hole, *s*, into which the tube, S, is soldered.

Other forms of air chambers may be used, but these here given are simple, have a very large metal surface, and occupy little space. In all cases where air chambers are used, the colder or more dense the air is when it is sealed in by the cup and glycerine seal, the greater will be the expansion when heated; but if in any case sufficient expansion, or power, cannot be had from air alone, the addition, when cold, of a few drops of any of the fluids before mentioned in connection with capsules will accomplish the purpose.

THE DISPOSAL AND UTILIZATION OF BLAST FURNACE SLAG.*

By Mr. WILLIAM HAWDON, of Middlesbrough.

Production of Slag.—While it is sometimes difficult to realize a profit in disposing of the pig iron produced from the blast furnace, it is almost always difficult to avoid a loss in getting rid of the slag made in conjunction with the iron. In other words, it is only under exceptional circumstances that the slag can be sold as a useful commodity and a profit be made from it. As a rule slag has at a certain cost for labor to be tipped over more or less valuable land, which is thereby covered up and wasted; or in some cases it has to be carried quite a way from the locality of the blast furnaces, at a further cost of carriage. Thus the disposal of slag from the blast furnace has almost always entailed a cost which has had to be reckoned in the manufacture of pig iron; and when it is borne in mind that about ten million tons of slag are made yearly in Great Britain, it will at once be seen that the aggregate amount of this cost is enormous, and that the subject is well worthy of attentive consideration.

Uses of Slag.—In some few localities a profit is realized by selling slag as a material for road making. It is first of all run in its molten state into balls, formed in the usual boxes, and carried away on bogies, from which it is tipped; when cool it is broken into pieces of the requisite size and sold at whatever profit can be obtained. At a few blast furnaces bricks for paving are made, but only to a limited extent. Where the traffic is not too heavy they are found to stand fairly well, as in stables and stable yards, and in the back streets of towns; in Edinburgh indeed some of the better streets are paved with them, notwithstanding that granite can be obtained near at hand. Slag is also cast in various forms, such as channels for water courses, curbs for footpaths, etc. Glass has been made from it in small quantities, but the author believes not on a commercial scale. The whole, however, of the slag utilized for all other purposes than road metal amounts to only a very small percentage indeed of the total quantity of slag made in the country.

Previous Modes of Disposal.—In the Cleveland district, where probably some 3¾ million tons of slag are made per annum, the question of its disposal has received somewhat serious consideration, and has been solved in one of two ways; either land has been purchased at a high price, from £400 to £1,000 per acre; or the slag has been sent out to sea in hopper barges, and there deposited in deep water. In the early days of iron manufacture, slag used to be run into holes dug in the sand of the pig bed, into which a stake of iron had been fixed; and when the slag was set the lump was lifted out by a crane laying hold of the stake. Sometimes the slag was run into channels made in sand or ashes, and was afterward broken up by hand. But with the subsequent larger makes from the blast furnaces it was found impossible to clear it away by these means. Cast iron boxes were then placed to form moulds for the slag to run into, and iron bogies were run underneath them to carry them away; or the sides of the boxes were themselves mounted on bogies which formed the bottoms of the boxes. The slag is thus conveyed away in balls of 2 to 4 tons; when it is cool, the frame or sides of the box are lifted off the bottom by a crane, the bogie is drawn away to the tip, and manual labor is employed to bar the balls off, in order either to level up uneven ground, or to build up a mountain, which is carried to a great height, so as to cover as small a base as possible on the costly land.

When sent to sea, the slag had to be broken up by hand, and wheeled barrowful by barrowful into the hopper barge. But this was such costly work that means were devised for breaking up the slag balls by fixing in the center of the bogie a hollow casting; the idea being that, when the mass of slag cooled and contracted round this casting, the ball would break up into pieces small enough to be tipped into the barge without much injury to the vessel. The hollow core was cast about one-third the width of the ball, and was fixed firmly on the top of the bogie; and when the box or frame was placed on the bogie, the slag was run into the space surrounding the core. It was found in practice, however, that this also was too costly a procedure. The central castings soon became burnt and cracked and broken, and repairs were found to be heavy. Moreover, the slag balls did not break into small pieces, and occasionally into only two or three large heavy pieces, which wrought havoc to the plates of the barges, springing the joints so that the pumps had to be kept constantly going to keep the water out; and often a hole was smashed through the plates and the vessel disabled by a heavy mass of slag, falling as it did down a shoot placed at the height necessary for loading at high tide, and thus acquiring an additional fall of 14 or 16 feet when loading at low water. The idea of the central hollow core or casting for causing the slag to break up in cooling was no doubt a good one, and the plan was certainly an advance on the old method of breaking up the balls by hand.

In some few instances the American plan is adopted of running the slag in flushes into a "boat" or tank on wheels, lined throughout with fire brick; or simply into a ladle placed on a truck. In either case the slag is merely run or tipped out of the vessel containing it. If intended for further removal, it is run from the tank or ladle on to cast iron plates, so as to form layers of slag, which can afterward be removed by hand when cool. The cast iron core was first introduced by Mr. J. A. Birkbeck at the Acklam Iron Works, Middlesbrough. The hollow casting was made double pear-shaped in plan, and of the full height of the slag ball, with the finer ends or knife edges toward the front and back of the bogie, so that when the bogie was tilted up, the slag, which had already cooled and cracked through contraction round the core, was cleft in two or more pieces, and fell into the barge. But these pieces were too large and heavy to be thrown with safety into the vessel. A vast amount of thought and money was expended by Messrs. Cochrane & Co., at the Ormesby Iron Works, Middlesbrough, in their endeavors to bring to a successful issue this method of breaking up and loading the slag. They introduced as a central core what they called a "hog back" casting. By this plan the slag was broken up into much smaller pieces than by Mr. Birkbeck's. After the slag had been run and had solidified, the bogies were placed under a series of perforated pipes, from which sprays of water played on the top of the still hot mass; the sudden cooling assisted in cracking the balls, which contracted round the hog backs. But although not so costly as the old plan of breaking the balls by hand labor and wheeling the slag into the barges, it was not satisfactory, the wear and tear, especially of the hog back core, being very great. This method has now been abandoned, and replaced by the apparatus about to be described.

At the Normanby Iron Works, Middlesbrough, where also the slag is sent to sea, Mr. Edwin Jones has built iron bogies with wrought iron sides about 15 inches high, and widening outward from the bottom. These are filled with slag, and when it is sufficiently cooled are run up to the slag shoot, and tipped up bodily so as to shoot the block of slag out, and let it fall upon knife-edged iron castings, by which it is broken up into somewhat large pieces; these then roll into the barge, or into a large hopper shoot fixed so as to store about 100 tons of slag. Still, however, the pieces are too large for the safety and wear of the barge. Several mechanical contrivances have been designed to deal with molten slag, the earliest probably being that of Mr. Thomas Bell, at the Walker Iron Works, near Newcastle-on-Tyne. As there was little land adjoining the works, he designed about 1871 or 1872 a machine for running the slag into such small pieces as could be readily handled and tipped into barges at the wharf adjoining the works, and thence sent to sea. The slag was run into a series of cast iron trays, each about 3 feet wide, which were fixed on an endless horizontal belt traveling a distance of about 12 feet. When the slag was sufficiently set or cooled, water was played on it to cool it further, and it was then tipped into trucks. For some reason unknown to the writer this apparatus was abandoned.

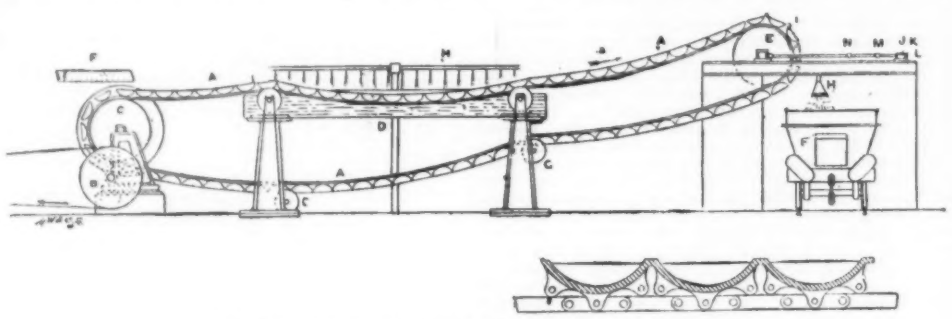
In 1873 designs were submitted to the Cleveland ironmasters by Mr. David Joy, who read a paper to the Cleveland Institute of Engineers, describing his plans, none of which, however, so far as the writer is aware, were put into practice. One idea was to have long endless belts running from the furnaces to the river for shipment. The belts were to consist of iron plates one-fourth inch thick, fixed on iron ropes; it is needless to say that those would have been too light to resist the action of molten slag run upon them. Another design was for disintegrating the slag by running it into water, out of which it was to be dredged by an arrangement of buckets. Other designs were also drawn out for running the slag into moulds fixed on the inner side of a horizontal wrought iron drum, which revolved on small rollers: the idea was to assist the cooling of the slag by means of water jets, and to carry it in the moulds nearly up to the top of the circle described by the revolution of the drum, and then to tilt it out into a trough shooting it into trucks. An experimental machine constructed on this plan could not deal with such a large flow of slag as was discharged from the furnaces of that date, and it does not appear to have been put into practical use.

Utilization of Slag.—To the utilization of slag a good deal of attention has been given by Mr. Charles Wood, of Middlesbrough, by whom several machines have been designed for dealing with it in this direction. In a paper read before the Society of Arts in London in May, 1880, Mr. Wood described several appliances which he had designed with this object. The first is a machine for making "slag shingle," and consists of a horizontal annular table about 16 ft. diameter, which is formed of segments or cooling plates about 2 ft. wide, made of cast iron, and having wrought iron pipes cast in them, through which water flows. While the table is revolving slowly, the molten slag is run upon it, and spreads out to a thickness of from three-fourths to 1 in. When it has traveled about 10 ft. and has consolidated, water is run upon it to cool it further; and then a set of scrapers push the slag off into iron wagons, into which it falls in small pieces. This machine is largely used for making concrete.

Another machine is for making slag sand, and consists of a wheel or short drum, the outer rim of which is trough-shaped and about 14 ft. diameter, revolving on a horizontal axle. Into the lower part of the trough-shaped rim, of which the opening faces inward or toward the center, water is run to a depth of 18 or 24 in., and into this water the molten slag is run, where it forms into a spongy sort of sand. Perforated shelves or elevators are fixed radially across the trough at intervals all round the wheel, and in passing through the water carry away the sand and lift it to the top of the machine, where it drops into a spout and is shot out into wagons. This sand has been extensively used for making concrete bricks which are useful for structural purposes; some millions have been sent from the Tees to London for house building, and have sometimes been sold at a profit at as low a price as 10s. or 11s. per thousand. In many parts of the country cement mortar is made from slag in this condition, and is very tough and durable.

Another form in which blast furnace slag has been usefully applied by Mr. Wood is that of slag wool or silicate cotton; and he appears to have been the first to manufacture it in this country on a commercial scale. The process is interesting and extremely simple. According to his own description in the paper already referred to, a jet of steam is made to strike upon the stream of molten slag, as it flows from the usual spout from the furnace. The steam scatters it into shot, and as each shot leaves the molten stream it draws out a fine thread; just in the same way as when treacle is touched lightly with the finger, it is drawn out into a fine thread. On losing its heat the fine thread of slag drawn out by each shot becomes set like glass. The shot itself being heavy drops to the ground, but the light thread is sucked into a large tube by an induced current of air. The finer qualities float about and settle near the outside of the chamber, while the heavier or larger fibers lie chiefly in the center. The wool is then ready for use, and is packed in bags for sending away. It is principally used for covering boilers or steam pipes, for which purpose it is peculiarly adapted, being a splendid non-conductor of heat and incombustible. As only one-quarter of a cwt. is made from each ton of molten slag operated upon, it will be seen that the process is not a very rapid one.

Endless-chain Slag Machine.—The disposal of slag by mechanical means engaged the writer's attention more particularly in the year 1885, when all the land available for slag tipping at the Newport Ironworks of Sir B. Samuelson & Co., at Middlesbrough, had been pretty well filled up. He then designed the apparatus



HAWDON'S BLAST FURNACE SLAG MACHINE.

illustrated above. A A are two endless chains, made of long steel or iron links, which are fastened together by pins or rivets. B is the primary driving shaft, driven by a small engine, or if more convenient by a belt. The endless chains pass over a pair of pulleys at C; they are driven from the shaft, B, by geared wheels, and cause the chains to travel in the direction shown by the arrow. The pans which carry the slag are fixed on the chains. They are shown in cross section in the smaller illustration. They are ninety in number, and are each made in three pieces, and are bolted on the chains, A, by means of two lugs cast on the bottom. The slag is conveyed from the furnace by means of the trough, F, from which it flows in a molten state into the pans as they travel beneath it. The pans then pass through the water trough, D, after which the slag is still further cooled by being sprinkled with water from the perforated pipe, H. Finally, in passing over the pulleys, E, the slag is tipped out of the pans into a shoot discharging into wagons beneath. For taking up any wear on the chains, a worm wheel and screw fixed at J are connected by links, K, to the pulley shaft, E, whereby the chain can at any time be tightened as required.

At the Newport works the eight machines are each driven by a steam engine with single 5 inch cylinder; but only about half its power is really necessary for driving them. The chains are run at slightly varying speeds, according to the output of slag, the average rate being about 13 ft. per minute. The eight machines together deal with 1,000 tons of slag per twenty-four hours. In the water trough, D, into which the pans dip down with the chains after passing the bearing pulley, G, the water is kept at a level reaching about two-thirds up the sides of the pans, and being kept boiling by the heat, a certain portion of it usually splashes over into the pans and assists in cooling the slag; but this is not essential to the process. Two or three trucks are kept in reserve on a slight incline, so that when one truck is full another is lowered into its place without stopping the machine. The trucks are made with bottom doors, or with side or end tip, to suit the particular requirements of the works where they are employed.

At casting time the slag which may follow the iron at the end of the cast is run into cast iron troughs, and when cooled is broken up by the slagger and thrown into the trucks, so that bogies and boxes are dispensed with in the general working of the blast furnace when these machines are employed. There is thus a considerable saving in labor, and in wear and tear of machinery and material employed in the disposal of slag from ordinary blast furnaces. Burst balls of slag,

* Paper read before the Institution of Mechanical Engineers, February 5, 1892, with discussion thereon.—*Iron.*

which might burn up the sleepers and roads and cause labor, are unknown. It is now no longer necessary to bar the balls off the trucks at the tip; and the constant repair, renewal, and shifting of rails and sleepers on the tip are now unnecessary. Two men per shift do the whole of the work required for the disposal of 6,000 to 7,000 tons of slag per week at the Newport works, with one locomotive per shift, which is assisted on the day shift only for one half the time by a second locomotive, thus averaging 1¼ locomotives per shift, in place of three locomotives when tipping on a mountain of slag. The enormous wear and tear of bogies and boxes due to hot slag is now done away with; and the wear on locomotives is reduced to a minimum, the dust and dirt due to the old method being dispensed with.

The slag is run into the pans about 1 to 2 inches thick, and breaks up into pieces from the size of a nut to a few pounds weight. It is largely used for road making, especially for the foundation of new roads. For concrete, being already small in size, it requires little further breaking to render it suitable, and for this purpose it has been found to be particularly adapted, some thousands of tons having been used for the walls of piers, wharves, etc., and also for the walls of buildings.

Experiments are now being made on a large scale with the view of using it extensively in the manufacture of cement, and it would appear likely to be largely used in future for the purpose. Not that it is a new idea to use slag for cement making, but the form and consistency into which it is run and manipulated in this apparatus adapt it in a special manner for cement manufacture. The slag is annealed or tempered in passing through the water, and that made from hematite iron, for instance, which contains a high percentage of lime, does not fall away into dust, as it otherwise does when run into balls and exposed for a short time to the atmosphere. In some districts vast quantities of ballast are brought for miles, and obtained in the first instance at some cost, for packing the sleepers of railways, which actually run past the very furnaces where the slag can so easily be made useful for the purpose. On the Northeastern Railway, which forms a network throughout the Cleveland and Durham districts, ashes from the ironworks and coke ovens are universally used. This ballast retains a lot of rain and surface water, and tends to rot the sleepers, and where steel sleepers are used, nothing is more injurious and wasting. Were this slag used wholly or in part as ballast, a drier and more lasting road would be the result. On many railways the larger class of ballast is used entirely, and in some cases slag is the material chosen. There appears therefore to be a wide opening for the use of this material, which in most localities is at present a nuisance and a source of expense.

The apparatus now described is a simple contrivance having probably no great merit as a mechanical device; but few things are more difficult to deal with than the force of expansion and contraction in metals, especially when brought about rapidly and with continuous alternations. This is the case at blast furnaces in any mode of dealing with the slag, and particularly so when artificial cooling is resorted to, and though at last simplicity has now been arrived at, a good deal of time has been occupied and many devices tried, before the desired result has been reached. Wear and tear, consequent on the rough usage which such apparatus is necessarily subjected to, require to be met by special consideration in the design of the different parts. Cheapness of manipulation being a matter of vital importance in iron manufacture, any apparatus or any method of treating the materials which realizes this object lays claim to the best attention not only of the makers of iron, but also of engineers generally, by whom this metal is so largely employed in all their works.

DISCUSSION.

Mr. Joy produced some drawings, which he said he had placed before the ironmasters of Middlesbrough in 1871, in reference to the removal of slag. He said he had spent most of the summer in that year in examining the various methods by which slag was treated, and coal and other materials manipulated, in Hartlepool, Liverpool, and elsewhere. The first proposal which he brought before the ironmasters was that of a couple of steel ropes carrying little buckets. Another plan was to take the slag into large wheels, as shown in one of Mr. Hawdon's diagrams. The wheel received the slag at the bottom, and when it was nearly at the top dropped it over into a hopper, from which it slipped into the wagon. So far as it went the machine was very efficient. There was another of the same construction, only horizontal. In both machines the slag was treated with water, which made it boil into a sort of scum, so that it broke very readily. Another plan was a sort of ejector. Something of the same kind had been used by Mons. Boulanger in France to carry away the slag in the form of sand. He (Mr. Joy) thought that by blowing a current of air in the slag spout the slag would be carried away while fluid and dropped into spheres and practically thrown away as sand. It did so; but it left a residuum which was the terror of every one about the place—a little tail that was afterward found to be the right thing for making silicate of cotton, which was a very valuable product. Messrs. Wilsons, Pease & Co. took up the other wheel and paid him a royalty. The ironmasters formed a committee to decide which was the best plan to adopt. Several plans were tried, but the Tees Conservancy, wanting slag for their breakwater, offered to take an enormous quantity. The ironmasters then declined to put their capital into the concern and it dropped to the ground. The labor, however, was not wasted, because a great deal had been learned. For himself he came to the conclusion that one of the wheels was better for each furnace, because if a wheel was wrong it could be taken away and another put in.

Mr. Jeremiah Head said that the greatest consumption of slag for any useful purpose in the Cleveland district had been for the making of breakwaters, especially by the Tees Conservancy. Large blocks had been made artificially, and floated out, weighing, he believed, about 250 tons each; but even these in a heavy sea were sometimes found to have been slightly shifted. The breakwater had been once or twice damaged, but the interstices had been filled up, and he believed it was now in a good condition. Another was being made in the same way. At Hull also embankments and other structures were being made of slag. With regard to the heaps of slag taken some miles out to sea, although the heaps might rise to a great height, it was found that they quickly spread about as soon as a heavy gale occurred. He had been one of the unfortunate directors of a company formed for making bricks of slag sand by mixing it with lime and pressing it into moulds. But although from an engineering point of view the bricks seemed to be very successful, getting harder as they grow older, the affair was not a financial success, and it was finally wound up. He believed that the manufacture of slag wool was still carried on by Wilsons, Pease & Co. It was composed of very fine threads, and was very good as long as it was new. It was silicious, and had good non-conducting properties. He had seen some taken off the tops of marine boilers after some time, and a curious effect was produced. The heat of the boiler seemed to anneal the little films, and they settled down into a very close, compact mass, looking like a lump of glass. He should doubt whether it fully retained its non-conducting qualities. The annealed bricks were an important industry. They were formed by running molten slag into iron moulds, and then, before they got cooled, running them into a kiln and allowing them to cool about ten or eleven hours. The effect was to make them exceedingly hard. If the moulds were allowed to cool quickly in the open air they would fly to pieces. The bricks were very useful where a road crossed a footpath, or in some by-streets in towns where there was not a great deal of traffic, and where they could be used for paving right across, making a nice, clean finish. He believed that some of them had been sent to London, although he had never seen any laid down in the streets. Several attempts had been made to make slag into Portland cement, and apparently with good results. The late Mr. John Fowler, the Tees Conservancy engineer, had a strong belief in cement made in that way. A Swedish gentleman named Larsson had proposed to grind the slag to an exceedingly fine impalpable powder, to make a hard-setting cement. His method was to put it into an iron cylinder with a number of spherical balls inside, which, tumbling over and over among the material, ground it very fine. That, however, was not a commercial manufacture at the present time. He thought that Mr. Hawdon's apparatus had been brought to a great state of perfection, and was doing its work perfectly well, taking the stuff away as fast as it was made, and putting it into trucks in a form in which it could be removed at once. There were hardly any men about it, and there did not seem to be any great wear and tear, or any considerable quantity of water used. The method only wanted to be better known to get into almost universal use.

Mr. Marten said that there was a great quantity of slag in the district of South Staffordshire. The great use made of it was in the pitching of streams. Almost a hundred miles of pitching had been done entirely with broken slag, in whatever pieces they could get it, using it as mere surface pitching, and they were surprised to find how exceedingly well it stood. It was a great deal better than bricks, which often perished in a frost. There were places which had been done ten or twelve years, and were in the same condition as at first, although they had looked very unpromising at the time. In some of the older ironworks a number of walls had been built with the slag, and so long as it was not disturbed they remained very well, but if one block fell out, it generally tumbled into small pieces. For the purpose of foundations it was nearly useless, because it fell to pieces so easily. He had been surprised that the Northwestern and Great Western Railway Companies had put up large shops for breaking slag into small pieces for ballast, which was done at great cost. He was also surprised to see the enormous heaps of very fine slag which it was said were useless, but it was certainly useful in road making or path making. If it was worth while to use slag of such fine material for ballast, it would surely be worth while not to let it get into large lumps to be broken up again, but to treat it as described in the paper. He was one of those who thought that, although the paving bricks might be very sound and lasting, they would make a very rough road for horses and pedestrians.

Mr. Perry F. Nursey said he had seen many of the methods in use for the utilization of slag. The most obvious method, he supposed, was that of breaking it into small lumps and using it for road metal. He had seen slag applied in that way at Middlesbrough some years ago, but it was not successful, and it was very damaging both to horses and vehicles. He had also seen walls built from slag balls, which were very beautiful and solid, but beyond that he believed the erection of walls did not go. With reference to the use of slag for ballast on railways, he had seen in Germany and France a simple method of disintegrating the slag by simply running it into a stream of water, after which it was shoveled aside and put into trucks and used for ballast purposes, for which he imagined it would be very useful. Some thought that it might become too rigid in the course of time. It might be too solid for the high speeds in England, but probably it would not affect the lower speeds in vogue on the Continent. He had been interested in seeing slag wool made. It had a very beautiful appearance, the whole of the shed in which it was made and the screens on which it was blown appearing as if covered with fresh snow. At Barrow a large addition to the steel works had been formed by tipping slag into the sea. The same thing was also going on at the new Dowlais works at Cardiff. It was not tipped into the water there, but the land was being raised to a high level by the use of the slag obtained from the furnaces. In the same way it had been very judiciously utilized at the Clarence works, where a very large area had been added to the property. It was interesting to watch the development of anything that would prevent the increase of slag heaps, and the apparatus described in the paper appeared to be one that was working satisfactorily in that direction.

Mr. Tomlinson said that nearly all the large railways were now coming to use slag. All the railways in Wales near the ironworks were entirely ballasted with it. Unfortunately, however, it lasted so long that the railways did not get rid of all that was made.

Mr. Bauerman said that the system of making large blocks was a great mistake. The true principle undoubtedly was that of the older system of furnaces, running the slag into small masses, and getting it away as quickly as possible—a plan that seemed to be carried out in a very perfect manner in the machine described. It was wonderful to see the large furnaces in the enormous works in Cleveland making such great quantities of cinder and disposing of it. The best plan was the American one of heaping, running it over the ground. The great thing was not to have too much cinder. He was very much pleased to see the system adopted in South Wales, where they took a very small quantity in an ordinary ladle, such as that used in taking metal to a Bessemer converter; then running it over the ground it could be run out in small quantities of more than half an inch or three-quarters of an inch, so that it would set very quickly. It could then be broken up and handled as conveniently as gravel or ballast. The machine described by the author appeared to be based on a thoroughly good principle.

Mr. Hawdon, in reply, said he could not help thinking that the thin plates of the machine referred to by Mr. Joy would soon be burned through. With reference to Mr. Head's remarks as to the "unfortunate" company that made slag bricks, he had understood from Mr. Wood that it was a great success, and that the reason why it was abandoned was that the Northeastern Railway Company bought the land. With regard to the pier built at Mr. Hutchinson's works, it had been stated in a paper read before the Society of Arts that 85 or 90 per cent. of the Cleveland slag was used in the cement. It was made into a sort of sand, and not in the manner described in the paper. He had been told by some manufacturers that they greatly preferred it made in the form of the specimen he had exhibited, which was much more easily dealt with. Instead of being in fine sand and filled with water, it was perfectly dry and very easily ground. There was no doubt an enormous waste in throwing slag away. There were twelve million tons of slag made per annum, and the great bulk of it, in many parts of the world, was entirely wasted. The machines at Newport made about 1,300 tons of slag per week with one of the furnaces, and the machine described in the paper dealt with it. The cost of it was about £200 or £220, and the cost of producing the slag, without including the locomotive drivers, was about 2s. 8d. per ton of iron, or 1·3d. per ton of slag. As to the American method of using slag at the Dowlais works, the objection to it was that the trucks were sculled very much, which required a great deal of labor and cost. They had also to break up the slag after it was run into fine layers.

Professor Kennedy said that it was obvious that Mr. Hawdon and his coadjutors and predecessors were anxious to do with iron what had been done with gas and one or two other matters, viz., to make a material which could be sold for nothing because so much profit was made out of the by-products. They had not quite reached that point, but in the meantime, to every one who made a practical step toward it, the whole engineering world was indebted.

CAST IRON.

ON February 11, Mr. Thomas Turner delivered the fourth of his course of lectures on the above subject in the chemistry lecture theater of the Mason College, Birmingham.

The lecturer remarked that castings were sometimes made from iron taken directly from the blast furnace in the fluid condition. But this method was only used to a very limited extent, and was becoming relatively of less and less importance, as irregular results were obtained, owing to the variations in the character of the iron made in a blast furnace from day to day, or even from hour to hour. So that even when founders are also ironmakers it is the custom to remelt the pig iron after its uniformity of character has been checked by fracture, or by analysis if necessary. On the small scale, for special purposes, gas furnaces are convenient for melting cast iron, but their use is limited, as the cost of gas is generally too high to allow of the application of gas on any considerable scale. Wind furnaces with fireclay crucibles and coke for fuel are in use in many cases were small castings are made; and where great uniformity is necessary a reverberatory or air furnace is employed. But in the vast majority of cases a small blast furnace, called a cupola, is used, as it is cheap, rapid, and easily managed. The coke should be hard and as free from sulphur and ash as possible. The amount of coke used will depend on the quantity of iron melted in a given time, and on the construction of the cupola. It may be reduced to as little as cwt. of coke per ton of iron melted. Usually, however, from 2 to 3 cwt. is employed. In addition to the simple form of cupola so long in favor a number of improved varieties have been introduced during the last few years. In Germany the Herbertz cupola has met with much favor, but has not succeeded in making its way in this country. It is worked with a steam exhaust, instead of with a forced blast, as is usual. Where large quantities of metal of uniform quality are needed, a cupola with a receiver or mixer is to be preferred, and Stewart's "Rapid" answers very well.

As the applications of cast iron are almost indefinitely numerous, and despite the competition of steel appear to increase rather than diminish, the difference in form and variety of moulds is very great. The most general material used for moulding is green sand, a black mixture to be found in every foundry, and which gets its name from the fact that it is used in the raw or unbaked condition. For special purposes dry sand, loam, or cast iron moulds are needed, but the Staffordshire district is famous for green sand moulding for brass, iron, and other metals, and for the improvements in details which have been introduced in order to allow of the production of a large number of the same class of patterns in the shortest time. Moulding machines are now being rapidly introduced into many branches of the trade where there is much repetition of simple forms, and it is stated that by this means the cost of moulding can, in some cases, be reduced to about one sixth of what it formerly cost. The effect of remelting cast iron varies with the character of the metal and with the method of melting. It has been frequently supposed that iron was improved by being melted and kept in the fluid condition, but Mr. Turner's analyses of the test pieces prepared by Sir W. Fairbairn have shown that the effects obtained can be fully explained by the chemical changes that took place, and that the

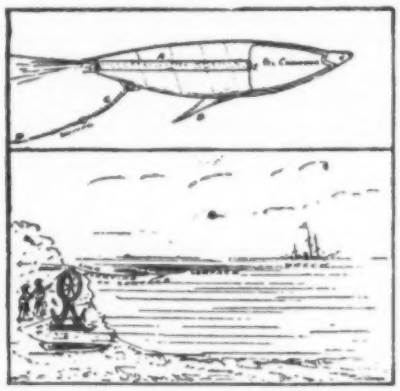
metal loses silicon and absorbs sulphur when it is remelted in the cupola or air furnace. This makes the iron harder, and if it were originally too soft, improves it, while if the metal were too hard at first, every melting only makes it worse. The properties of cast iron are not altered when it is melted in a closed vessel, so as to prevent chemical change. The various kinds of cupolas, moulds, etc., were illustrated by the aid of lantern views.

LIFE SAVING DEVICES.

THE proprietors of the London *Daily Graphic* recently offered a premium of $500 for the best suggestions for devices for communicating between the shore and stranded vessels, in response to which a number of plans have been given in the *Graphic*, from which we select the following:

A SEA ROCKET.

Commander Aylesbury describes his invention as a sea rocket. He has recently submitted it to the Board of Trade for their approval. It is a torpedo propelled by an explosive, in composition similar to portfire, and timed to distance. To the torpedo is attached a coir line wound on a drum on shore, which the torpedo unwinds as it goes seaward. When the whole charge is



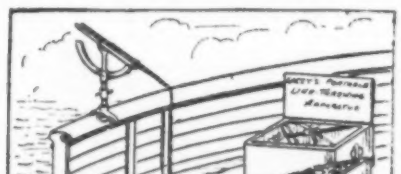
a. Charge tube, with contents, graduated to distance. *b*. Fluke fin. *c*. Chain connected to coir line. *d*. Coir line (which will float) for connection with ship or shore. *e*. Fusible plug which, when charge is burnt out, distributes the oil.

SEA ROCKET TORPEDO INVENTED BY COMMANDER T. W. AYLESBURY, LATE OF THE INDIAN NAVY.

burned out, the fusible plug is released, and the oil escapes to smooth the waters. The torpedo should be sent to windward of a wreck if possible, and those on board could pick up the line with a grapnel. Should the torpedo be sent from the wreck to the shore, the fluke fin will grip the ground. The torpedo would be partly submerged, and the upper part or back would be painted with luminous paint to be distinguishable in the dark. The whole could be made of thin iron sheeting or spelter, sleyed to the charge tube.

PORTABLE LINE-THROWING APPARATUS.

Mr. R. G. Lacey, late of the Royal Navy, sends us an invention which he calls his portable line-throwing apparatus. "It fits compactly into a portable box, very simple and commodious in construction, and by an easy device the line may be instantly set loose and run

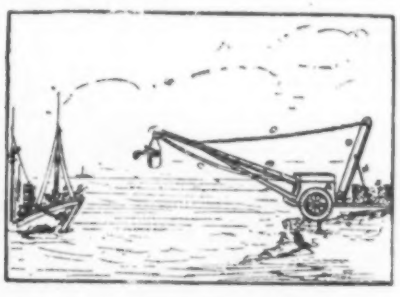


LACEY'S PORTABLE LINE-THROWING APPARATUS. (From a sketch by the inventor.)

out to its full length without the slightest friction or obstruction. The range of the rockets is from 250 to 300 yards, carrying ⅛ inch tarred manila floating line." He adds that the adjustable socket or clutch, by which the firing trough is attached to the rail, is a clever mechanical device allowing attachment to be made at any part.

A FORTY-FOOT TELESCOPE.

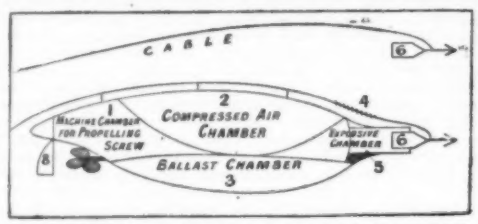
Mr. J. Reynolds, Jr., sends us what he calls his



REYNOLDS' "GRAPHIC" LIFE SAVING APPARATUS.

Graphic Life-saving Apparatus. In the description we can only follow Mr. Reynolds' lettered details, thus: A, iron caisson; B, wrought iron telescope to be extended by means of hydraulic pressure from caisson; C, traversing ropes for basket gear, these two ropes to be attached to the end slide of telescope prior to extending it; D, brace or standard with running and winding gear to relieve strain on telescope, which may be raised or lowered by means of winding winch in rear of caisson; E, ballast box, to be weighted with shingle when in position, load to equal fifty to a hundred tons as counterweight; F, two guide ropes to vary position of telescope spar (worked by winding gear); G, life basket, from which lines or rocket can be thrown to stranded vessels; H, additional wire rope or brace to strengthen brace, D; I, pair broad wheels for traveling. He adds that a four-jointed spar could be worked upon a somewhat similar principle; each spar to be thirty or forty feet in length.

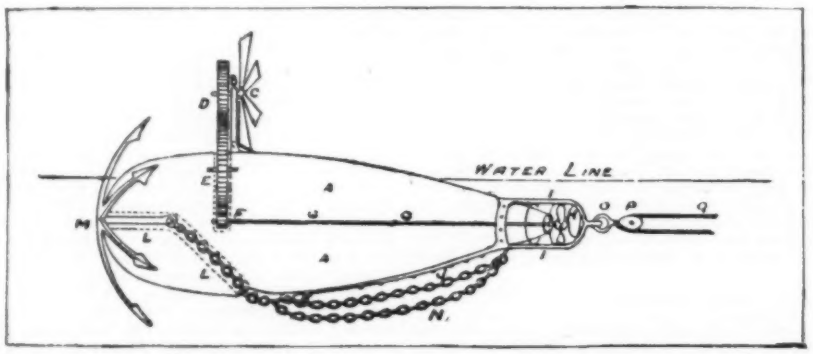
Mr. Oliver Best sends a design of a torpedo-like vessel, intended to carry a line ashore from a stranded vessel. Mr. Best says that this vessel is "to be made of sheet steel, the head to be similar to the mouth of a



A TORPEDO INTENDED TO CARRY A CABLE ASHORE.

cannon. The shear-shaped anchor (6) is to be the projectile, and the charge is intended to explode as soon as the head of the anchor comes in contact with land or any other substance. The base of the anchor is to be sufficiently heavy for an ordinary man to cross the cable from the stranded ship with a buoy, provided there is no one on shore and the anchor failed to grip. The explosion would give the alarm of distress. The coil (4) is to prevent the cable from being broken when the anchor is discharged. The apparatus is similar in shape to the body of a mackerel, and would be perfectly watertight. The upper portion (2) is to be a chamber filled with compressed air to keep it from rolling over. Fig. 8 is the helm, and the other compartments have their use indicated by the names upon them. The length is to be about 8 ft. or 9 ft. or more."

Mr. Henry Wall calls his device a screw buoy and grapnel, and in forwarding it to us says that objections may be raised to the screw buoy on the ground that it

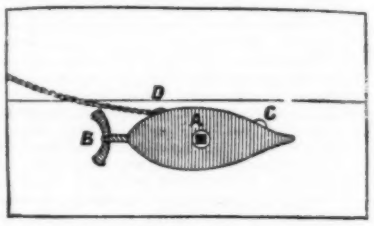


THE SCREW BUOY AND GRAPNEL. (From a design by the inventor, Mr. Henry Wall.)

can only be used when the wind is from the vessel to the shore, but it must be borne in mind that with the wind seaward there is seldom, if ever, sufficient sea to prevent the use of boats. He adds: "Many experiments which I have made have proved that the buoy can be made to carry the weight required without difficulty, everything being made to combine strength with lightness. With regard to the grapnel getting a hold when the buoy is ashore, I have only to say that there must always be an uncertainty in this whatever plan is adopted for sending the grapnel ashore when there is no one there to secure it."

The design is thus described: A A represents a buoy constructed of cork, and strongly sheathed outside with wood. On the upper part is a metal pillar, B, on which work the sails of a windmill, C. The spindle of the sails passes through the pillar, and carries a cog wheel, D, on the other side. This cog wheel works again in another and larger one, E, which again works in a small cog wheel, F, which is attached to the shaft, G G, which runs through the center of the buoy, and carries a small four-blade screw propeller, H. The dotted lines in the diagram show the space in which the cog wheels work. On the after end of the buoy is fitted a metal bridle, I I, the lower leg of which, J, runs along half the length of the buoy underneath, and ends in the eye, K, to which is attached a length of chain. The other end of this chain is passed up the tube, L L, and out at the front of the buoy, where it is attached to the grapnel, M. The chain, on being hauled taut underneath, draws the shank of the grapnel into the tube, L, until the flukes are close up to the head of the buoy, as shown in the diagram. A link of the chain must then be stopped to the eye, K, with a twin stop strong enough to hold the grapnel in its place. The bight of the chain, N, can then be stopped up to the bridle, I, as shown in the diagram, in which position it will keep from fouling, and at the same time help to ballast the buoy. The bridle, I I, has an eye in the bow, O, to which is attached the swivel block, P, through which is rove the line, Q. The windmill pillar, B, can be made to work on a hinge close to the buoy, so that it will fold down with the sails and cog wheel, D, for storage. The propeller can be protected from the chance of fouling by light iron hoops from the bridle. A number of minor details are omitted.

R. S. V. P. suggests "a small steel torpedo containing a powerful spring which, upon being wound up,



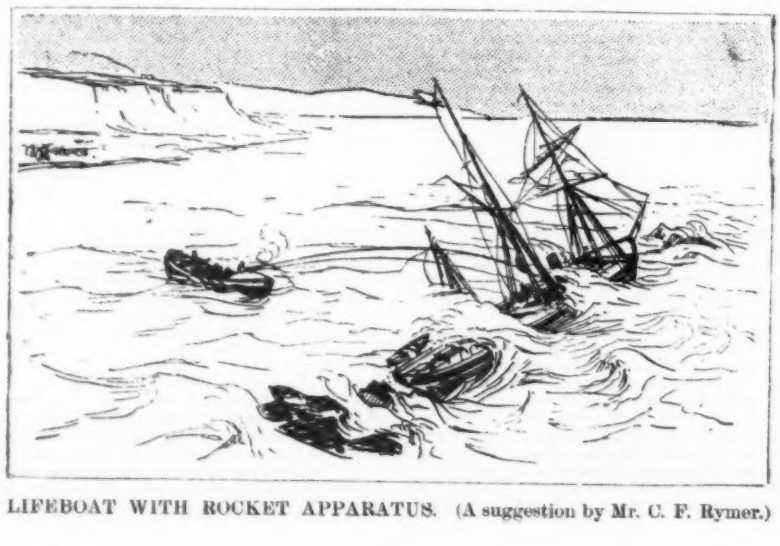
a. Keyhole with watertight lid. *b*. Screw propeller. *c*. Handle for pulling torpedo ashore. *d*. Ring with cord attached.

A CLOCKWORK TORPEDO.

(From a sketch by the inventor, "R. S. V. P.").

will work the screw and carry a cord toward land. A flag might be added to the top, in order that those on shore might distinguish its course through the water."

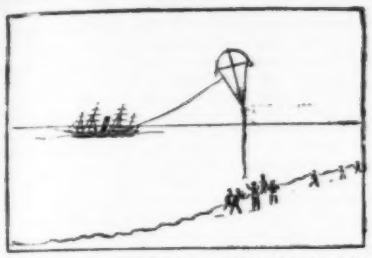
Mr. C. F. Rymer throws out the suggestion in a sketch, from which the one below is taken, that the lifeboat itself should be provided with a rocket apparatus. Then, after she has obtained position, within one or two hundred yards of the wreck and inside the reef, she should discharge a rocket across the ship. The rocket could carry a double line, and this, having been passed round a spar of the ship and secured by a pulley to the boat, would form an endless cord. This line would lie on the water. He adds: "I would suggest that one or two buoys should be attached to the line to prevent it sinking, and these buoys would be of great assistance to those passing from the wreck to the lifeboat. It



LIFEBOAT WITH ROCKET APPARATUS. (A suggestion by Mr. C. F. Rymer.)

might be desirable that a net should be attached to the buoys, to prevent any one being washed away. In extreme cases it would be possible for one of the lifeboat crew to reach the wreck by means of the line and buoys."

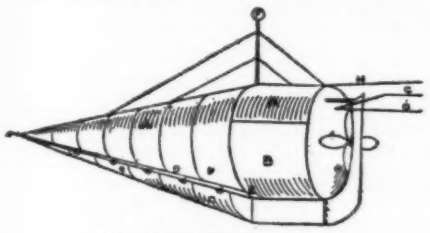
"Globe Trotter," whose idea of a kite from the ship to the shore we illustrate, writes: "If the wind is from the shore the rocket apparatus will work, but if the wind is from the sea—that is, from the ship—then why should not a kite be employed? It should have a



FLYING A KITE FROM A STRANDED VESSEL.
(A suggestion by "Globe Trotter.")

very long tail and the lightest cord, perhaps even thread. This would enable those on shore to secure the kite; the rest is comparatively easy."

An electric float is the invention of Mr. J. Hibberd. He gives the following key to the lettering: A, air chambers; B, electric engine; C, sand or a grapnel; D, rod to open the bottom to empty sand, etc.; E, rod to stop engine; F, electric light; G G, guide lines; H, communication line. The float, Mr. Hibberd says, could be made of sheet iron, and the fore part filled with air. The electric engine would propel the float along. The bottom part would open by "ketches" fixed to the opening rod. The space could be filled with sand or stones to keep the float under water while in motion, and as soon as the float struck a stranded ship the opening rod would slide the "ketches" back, the bottom would open and discharge the sand, and float would at once rise to the surface. Those on board could then make her fast and at once have communication with the shore. Or the float could be kept on board ship and be fitted with a small anchor or grapnel instead of sand, and a crooked bar attached to the



AN ELECTRIC FLOAT.
(From a sketch by the designer, Mr. J. Hibberd.)

opening rod as soon as it touched the ground would open and drop anchor. It could also be fitted with an electric light, by which its course could be traced.

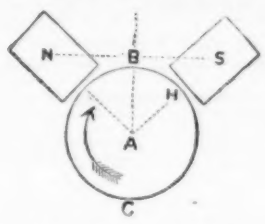
Among other suggestions which are not illustrated, Mr. W. Blomfield suggests that a kite should be flown from the shore to the ship. Mr. A. Warner thinks that as a torpedo can be sent from the shore to destroy a ship, one can be sent to save it. He would have it carry oil and a line instead of explosives. Mr. R. F. Crawford also thinks that torpedoes would save as well as destroy, but he would have them sent from the ship to the shore. Mr. H. E. Matthews, who sends a model, which has been returned, sends notes of his line-carrying life preserving apparatus, which carries a line by means of a rocket attached to a cylinder in which the line is coiled, and pays out as it goes to its destination. Mr. John Holloway, a defender of Lucknow—all honor to him!—also suggests the torpedo. A lady's idea is that of having a balloon on board with gas stored at high pressure in retorts. The balloon could carry a cord with anchor to the shore, and the anchor catching would open the valve and collapse the balloon. "F. G. B." names the Brennan torpedo minus the explosive as a means of communication. Captain Dalton thinks that the best thing is a life saving jacket stuffed with the hair of reindeer instead of cork. He says it is much lighter. Mr. Edward Clark's scheme is too elaborate to be shortly described. It involves windlasses, four or five thousand feet of rope, collapsible India rubber balls or a life buoy, and a metal sail. Mr. D. G. Swanson would fire a telephone wire attached to a projectile from a small cannon. Mr. A. H. Bartlett argues strongly in favor of the torpedo. "Sandwich Haven" mentions the case of the Sorrento, where the crew were saved by means of a cork fender, which drifted down with a line attached to the life boat, and a similar means of life saving was adopted in the case of the Glendura. This makes him suggest the drift buoy.

[NATURE.]

A SIMPLE HEAT ENGINE.

AT the last *soiree* of the Royal Society, a beautiful experiment was shown by Mr. Shelford Bidwell, illustrative of the fact that nickel ceases to be magnetic at a certain definite temperature. A piece of nickel was arranged as the bob of a pendulum. As long as the nickel was below a certain temperature it was held on one side by a magnet, but when it was heated by a spirit lamp flame beyond a certain temperature it ceased to be attracted, and passed out of the range of the flame; it then cooled, and almost instantly returned to its first position, again to be released by the heat of the flame. It occurred to me that if a disk of nickel were placed in a certain position in a magnetic field, and then heated, it would continuously revolve. This on trial I found to be the case.

The experiment was arranged thus: The nickel disk BC, 5 cm. in diameter and 1 mm. thick, was mounted on an axle passing through A; it was held in a frame so that the faces of the two poles, N, S, of an electromagnet were at right angles to one another; the heat was applied at H; the disk revolved in the direction shown. A great many different positions were tried, but the one indicated gave far the best results. The rotation began when the part of the disk above the flame reached 290° C. The distribution of the lines of force passing through the disk from edge to edge was examined by placing a sheet of a non-magnetic metal



above the disk when cold and when heated, and sifting iron filings on to it. When cold, the lines of force were uniformly disposed across it; but when the disk was heated, only a few appeared to pass through the heated region. From this it is evident that the fall on the heated side of the disk is always less than that on the side which is not so hot, and to this the rotation is due.

FREDERICK J. SMITH.
Trinity College, Oxford, December 31, 1891.

PORTABLE VERTICAL BORING MACHINE.

THE engraving represents a general view of a portable boring machine capable of boring a hole 8 ft. in diameter and 6 ft. 6 in. deep. The machine, which was made by the Northern Engineering Company, limited, Halifax, was designed chiefly for reboring marine engine cylinders in position, and is provided with the necessary rings and hooks for handling the same by means of wharf cranes. It is entirely self-contained, and is driven by a small engine shown, fixed to the top plate, the steam for which is obtained from any convenient source, such as a ship's boiler.—*Industries.*

PORTABLE VERTICAL BORING MACHINE.

BEARING METAL ALLOYS.*

By C. B. DUDLEY.

THE amount of metal used to make bearings is something enormous. To my knowledge one large corporation uses not less than 1,000,000 to 1,250,000 pounds per year of bearing metal, and it can readily be seen why this should be so from knowing that each bearing weighs from 10 to 15 pounds, and that each car has not less than eight, while some cars have 12. It is a fairly good bearing metal that will not lose as much as a pound of its weight in a single bearing for every 25,000 miles that it goes under a car.

There may be five characteristics of a good bearing metal:

(1) The bearing must hold up the load. It is doubtless well known that in railroad practice the pressure per square inch on the bearing metal is frequently as high as 350 to 400 pounds, and consequently it is absolutely essential that the bearing metal should be of such a nature that it will sustain this pressure without distortion.

(2) Another requisite of a good bearing metal is that it does not heat readily. Upon this point there is not as much information as could be desired. The general tendency of all the information which is at hand on this subject is that the harder the bearing metal is, the more readily it will heat, or, to put it in another form, the softer the alloy the less liability there is for the bearing to get hot in service.

(3) Another important requisite of a good bearing metal is that it shall work well in the foundry.

(4) A good bearing metal should show small friction. Upon this point it may be urged that the friction is almost wholly a question of the lubricant used, and all the experiments that I have seen confirm this view to a greater or less extent, namely, that the largest portion of the friction between a bearing and a journal is a function of the lubricant used. On the other hand, the nature of the bearing metal does certainly have an influence, and a good bearing metal is one which

* Abstract from the *Journal of the Franklin Institute.*

makes that element of the friction depending on the bearing metal as small as possible. I do not know of much experimentation on this subject. Such experiments are extremely difficult to make on account of the large number of variables, notably temperature, quantity of oil between the surfaces, pressure, speed, relative smoothness of the journal and bearing, etc. It is very greatly to be desired that careful experimentation in this field should be made.

(5) It is extremely important that a bearing should give high mileage with small loss of metal by wear. It has already been stated that the average bearing metal used under cars loses one pound for every 25,000 miles that the bearing goes. Many bearing metals wear much faster than this, and some slower, but, other things being equal, no one will dispute that that bearing metal is best which wears the slowest.

The common metals from which alloys are made for bearings may, perhaps, be enumerated as follows: Copper, tin, lead, zinc, antimony, iron, and aluminum.

Most people are aware that fifteen or twenty years ago the standard metal used in car bearings, and other places, was a simple copper-tin alloy, containing seven parts of copper to one of tin. Indeed, some railroads, if I am rightly informed, and some builders of machinery, even at the present time use cannon bronze or the seven to one copper and tin alloy as bearing metal. It will be seen as I proceed that we regard this as a serious mistake; that while perhaps we do not know what the best bearing metal is, we do know something very much better than the copper-tin alloy.

It will, perhaps, be essential to describe the method of experimentation before proceeding to show what modifications in the copper-tin alloy have been made use of in trying to throw some light on the question of the best bearing metal alloy.

The method in all cases has been to have a certain number of bearings made of a standard bearing metal, which will be described later on, and the same number of bearings of the experimental metal. These bearings were placed on opposite ends of the same axles, either on locomotive tenders or on cars, one-half of the standard and experimental bearings being on one side of the car and the other half being on the other side, but in all cases a standard bearing and an experimental bearing on opposite ends of the same axle. The bearings were all carefully weighed before going into service, and after a sufficient lapse of time were taken out and reweighed. At first an attempt was made to give the loss of metal by referring it to the mileage, but the described method of comparison was ultimately adopted, as giving results free from any possible difficulties introduced by mileage, so that all the results which we obtained are strictly comparative.

Of course, owing to the exigencies of the service, it sometimes happened that some of the bearings put in use were not returned to be weighed. Whenever, from any cause, a bearing was missing, its opposite was not taken into account.

The method was to compare the relative loss of metal by wear of various alloys with a certain standard alloy. It should be stated that likewise observations were made on the behavior of the experimental alloys as to heating. No observations were made as to the difference in friction with the different alloys. This field is entirely unexplored so far as I know. The first test was a comparison of the old copper-tin alloy with the standard phosphor-bronze bearing metal. The results obtained were as follows:

COPPER-TIN VS. PHOSPHOR-BRONZE.

	Composition Copper-Tin. Per Cent.	Composition Phosphor-Bronze. Per Cent.
Copper	87·50	79·70
Tin	12·50	10·00
Lead	none	9·50
Phosphorus	none	0·80

Wear.—First experiment, copper-tin wore 48 per cent. faster than phosphor-bronze; second experiment, copper-tin wore 53 per cent. faster than phosphor-bronze; third experiment, copper-tin wore 47 per cent. faster than phosphor-bronze.

It should be stated that the analyses are approximately average analyses, rather than special analyses of the samples in each test, and it will be observed that there is no allowance for small impurities of zinc, iron, antimony, etc. It will be observed also that in expressing the loss of metal by wear, the loss is given in percentages of loss of metal compared with standard phosphor-bronze. It is entirely clear, we think, from the above experiments that the copper-tin alloy of seven to one is nothing like as valuable as the standard phosphor-bronze for bearing metal, and this view is confirmed from knowing that the experiments above given were made on some hundred bearings of each kind, and that a much larger percentage of the copper-tin bearings heated than the phosphor-bronze. So satisfactory were these experiments that the phosphor-bronze bearing metal was for quite a long time used as the standard bearing metal for car bearings on the Pennsylvania Railroad. It was not deemed advisable to allow the matter to rest there, and accordingly experiments have constantly been in progress to secure modifications which would give better results. Just here I would like to call attention to two points. First, the copper-tin bearing metal differed from the phosphor-bronze in several particulars. First, there is less tin; second, there is quite a percentage of lead; and third, there is some phosphorus.

It is not intended to give the results of all the tests that have been made during the last fifteen years, but only a selection from them, as the tests given apparently illustrate a law, and show the development of our knowledge leading to present practice. Accordingly, the next experiment will be one which we think throws considerable light on the matter, namely, an experiment with arsenic-bronze. It has been found that arsenic practically takes the place of phosphorus in a copper-tin alloy. Accordingly, several experiments were made with arsenic-bronze. The results of these experiments are as follows:

First Experiment.

	Composition Arsenic-Bronze. Per Cent.	Composition Phosphor-Bronze Per Cent.
Copper	89·20	79·70
Tin	10·00	10·00
Lead	none	9·50
Phosphorus	none	0·80
Arsenic	0·80	none

Arsenic-bronze wore 42 per cent. faster than phosphor-bronze.

Second Experiment.

	Composition Arsenic-Bronze. Per Cent.	Composition Phosphor-Bronze. Per Cent.
Copper	79·20	79·70
Tin	10·00	10·00
Lead	7·00	9·50
Phosphorus	none	0·80
Arsenic	0·80	none

Arsenic-bronze wore 15 per cent. faster than phosphor-bronze.

Third Experiment.

	Composition Arsenic-Bronze. Per Cent.	Composition Phosphor-Bronze. Per Cent.
Copper	79·70	79·70
Tin	10·00	10·00
Lead	9·50	9·50
Phosphorus	none	0·80
Arsenic	0·80	none

Arsenic-bronze wore 1 per cent. faster than phosphor-bronze.

"K" BRONZE VS. PHOSPHOR-BRONZE.

	Composition Damascus-Bronze. Per Cent.	Composition Phosphor-Bronze. Per Cent.
Copper	77·00	79·70
Tin	10·50	10·00
Lead	12·50	9·50
Phosphorus	none	0·80

First experiment, damascus-bronze wore 8 per cent. slower than phosphor-bronze; second experiment, damascus-bronze wore 7·30 per cent. slower than phosphor-bronze.

It will be observed that the first experiment was practically a copper-tin alloy containing some arsenic, and that this wore very nearly as fast as the copper-tin alloy, seven to one. I have been accustomed to regard this experiment as indicating that the phosphorus in bearing metal alloys does not have very valuable influences on the wear, and seems to be more valuable in the foundry than in the service. This second experiment, it will be noted, differs from the first in introducing some lead in the alloy, and it is extremely interesting to note that, although the arsenic and tin remain the same as in the first experiment, the introduction of the lead produces a diminution in the rate of wear which is very marked. After this experiment was concluded, a third experiment was tried, in which the composition of the arsenic-bronze was patterned as near as possible after that of the phosphor-bronze, and it is interesting to note that in this case the wear of the two was almost the same. The heating of the arsenic-bronze alloys in service was no greater than the phosphor-bronze, and there were no other appreciable differences to be discovered in the behavior of the metal, except as the figures above show the rate of wear.

It is interesting to note that these experiments thus far made seem to indicate, first, that the introduction of phosphorus or arsenic into a bearing metal has very little influence on the rate of wear, while the introduction of lead has a very marked influence on the rate of wear. In view of these teachings, it was decided to extend still further the influence of lead on bearing metal. Accordingly, a bearing metal was obtained which contained still more lead than the standard phosphor-bronze. This metal we will call "K" bronze. The result of the experiment with "K" bronze is as given above.

This experiment, to my mind, is extremely interesting. It should be said that no trouble was experienced from heating with the "K" bronze more than with phosphor-bronze, and no other peculiarities, other than the rate of wear as given, were observable. There is no phosphorus in the "K" bronze, practically the same tin, and an increase in lead, and as the result of these changes, the "K" bronze, as will be observed, surpasses the phosphor-bronze in wear.

The value of lead in a copper-tin alloy for bearing metal being apparently so well established, it became a question of how much lead could be gotten into the alloy without running into difficulty. Also about this time there began to be evidences of a law governing the composition of all bearing metal alloys, which law may be briefly stated as follows: That alloy which has the greatest power of distortion without rupture will give best results in wear. In accordance with this law we started to design an alloy which would have as great a power of distortion as possible without rupture.

After experimenting somewhat, we finally decided on a proportion of copper and tin, about 9½ parts copper to 1 of tin. We have some evidence, obtained since the experiments I am about to give were made, that indicate that we could have gone still further and made the ratio of copper to tin 12 or possibly 15 copper to 1 of tin. The ratio of copper to tin having been established, the question of how much lead to use came up, and as a consequence the question of the influence of lead on a copper-tin alloy arose. I do not think that this point has been fully worked out, but as far as we have gone, the indication seems to be that the addition of lead has much the same influence on a copper-tin alloy that a still further diminution of tin would have. That is to say, if an alloy of copper and tin is made, 15 parts copper to 1 of tin, it will probably have much the same physical properties, and give much the same results in wear as an alloy of 10 parts copper to 1 of tin, which alloy contains quite a large percentage of lead. It should be stated here that as the amount of tin is diminished and the amount of lead is increased, the tendency of the metal to yield more readily under pressure increases, so that it becomes essential to guard against possible danger of having a metal which would yield too readily under the load. After considerable preliminary work, bearings were cast, and a wearing test made, the results of which are as follows, the new metal being called alloy "B:"

ALLOY "B" VS. PHOSPHOR-BRONZE.

	Composition Alloy "B." Per Cent.	Composition Phosphor-Bronze. Per Cent.
Copper	77·00	79·70
Tin	8·00	16·00
Lead	15·00	9·50
Phosphorus	none	0·80

PHYSICAL PROPERTIES.

	Alloy "B."	Phosphor-Bronze.
Tensile strength per sq. inch, pounds	24,000	30,000
Elongation, per cent	11	6

Wear.—Experimental alloy "B" wore 13·5 per cent. slower than phosphor-bronze.

It will be observed that this alloy wears considerably better than the standard phosphor-bronze, and the best of any in the series; also that it is lower in tin and higher in lead than the phosphor-bronze. It will also be observed that the physical properties of alloy "B" were taken in comparison with phosphor-bronze, and that the characteristics are that alloy "B" has a lower tensile strength but a greater elongation than the phosphor-bronze. It is well known that the elongation measures to a greater or less extent the capacity of the metal to suffer distortion without rupture. Some experiments have been made toward still further diminishing the tin and increasing the lead, but it is found that a certain amount of tin is necessary to hold the lead alloyed with the copper, and apparently the limit of the diminution of tin and increase of lead is not a great way from the composition of alloy "B."

The formula used on Pennsylvania Railroad in making the standard bearings patterned after alloy "B" is as follows:

	Pounds.
Copper	105
Phosphor-bronze, new or scrap	60
Tin	9¾
Lead	25¼

By using ordinary care in the foundry, keeping the metal fairly well covered with charcoal during the melting, it is entirely possible to get perfectly successful castings in car bearings on the above formula. The copper and the phosphor-bronze can be put in the pot all at once before putting in the melting hole. The tin and lead should be added after the pot is taken from the fire.

It is, of course, a fair question whether the introduction of a little zinc, or possibly some other combinations of the six or eight metals commonly used for alloys, will not give a bearing metal much better than the alloy "B." All that I can say on this point is that alloy "B" represents the best knowledge that we have on the subject at present, and the whole thing may be summed up by saying that at present the best bearing metal that we know of is a copper-tin-lead alloy, containing a small amount of phosphorus, in which the proportions of the constituents are approximately those shown above.

GEOLOGY OF THE TONGA OR FRIENDLY ISLANDS.

A VALUABLE paper on these islands of the South Pacific, by J. J. Lister, is published in the *Quarterly Journal* of the Geological Society, vol. xlvii., p. 500, June, 1891. The region of the group—whose length is about 250 English miles—is remarkable for the great diversity of level in the islands and in the ocean adjoining.

On the west side, along a course nearly N.N.E., the islands, from Amargura in 18° S. and 174° 25 W. to Honga Tonga in 20° 35' S. and 175° 25 W., are volcanic, and the heights occur of 1,890 feet in Lette I., 151 in Metis I., 3,030 in Kao, 1,890 in Tofua, and 300 feet in Honga Tonga.

Just east (30 to 40 miles), along an irregularly parallel line, occur: Vavau at the north, in 18° 35' S. and 174° W., with nothing but coral reef limestone in sight, and having on the N. and N.E. sides the limestone rock in cliffs 300 to 500 feet high; the Hapai group, consisting mostly of coral reef rock, 20 to 100 feet high; the Nomuka Islands, consisting of tufa, having coral reefs to eastward 30 to 60 feet high; at the south end, Tóngatabú,* in 175° W. and 21° 10 S., a coral island

* The accent is on the first and last syllables—the latter half being the Polynesian word tabú.

with a shallow lagoon, but raised 60 feet above the sea level on the southeast side.

About 10 miles to the southeast of Tongatabu is Eua, a volcanic island over 1,000 feet high at two points, but incased in coral reef to a height at one point, by estimate, of 300 feet, and another of 500 feet, and having cliffs of the limestone "some 200 feet high" along the eastern and western sides.

Mr. Lister's paper, which is illustrated by maps and sections, contains other facts of geological importance. He refers to the great depths of the sea to the southeastward and eastward of the group; to the southeastward 230 miles, in 175° 8′ W. and 24° 37′ S., 4,428 fathoms, and in 175° 7′ W. and 24° 49′ S., 4,295 fathoms; to the eastward of Vavau, 150 miles, in 172° 14½′ and 17° 4′ S., 4,590 fathoms. On the bathymetric map in this journal, vol. xxxvii, and also page 420, and vol. xxxix, p. 412, other soundings in the vicinity are given, but none have been obtained on the direct line between the two deep depressions.

The soundings make the total height of the summit of Kao above the deepest point in the ocean to eastward a little over 30,000 feet. Such depressions are not a result of loading the crust by deposition. The range of facts here reviewed indicates that some profounder method of causing change of level has been at work.—J. D. D.—*Am. Jour.*

THE OPERATION OF HIGH TENSION CURRENTS UNDERGROUND FROM A PHYSICAL AND FINANCIAL STANDPOINT.*

By E. A. LESLIE.

THE underground conduits in New York City for high tension currents are owned by the Consolidated Telegraph and Electrical Subway Company, who lease their ducts to the various electric lighting companies.

The prevailing type of duct is of iron pipe, mostly three inches in diameter, running along the sides of the streets into manholes about 275 feet apart. These are the so-called "trunk ducts." Over the trunk ducts are superimposed from two to four distributing ducts, with four-way handholes about 50 feet apart. Many of these handholes are brought to the surface of the street and are covered over with an iron plate, which is easily removable, giving ready access to the wires in the distributing ducts. In many places, however, the handholes do not approach the surface, and, in order to get at the wires to make changes or connections, it is necessary to dig up the street. Again, on some of the prominent streets no distributing facilities whatsoever have been provided and the companies are compelled to make long and expensive house connections from manholes. This is particularly true of Sixth Avenue above Eighteenth Street and Broadway above Thirty-fourth Street.

The Subway Company have also a number of miles of a system which is made up of sectional iron castings and so framed together as to combine in one conduit both trunk and distributing facilities.

These conduits have no surface handholes, and, in order to make changes or connections, it is also necessary to dig up the street. The manholes are about 275 feet apart, as in the case of the iron pipe.

There is also a small amount of conduit in use which is composed simply of cement-lined iron pipes, running from manhole to manhole, of about three inches inside diameter.

The cost of the New York conduits is an unknown quantity. The Subway Company guard the secret well, and, beyond the general statement that they have cost, on an average, nearly $5,000 per mile, per duct, no reliable information can be gained. In these figures, however, are doubtless included the expenses of years of legislation and long and costly litigation. It is the universal opinion among electric light men in the city that the actual average cost should have been less than $3,000 per mile of duct.

The companies with which I am connected use, principally, cables insulated with a rubber compound, although we also have in use 35 or 40 miles of cable the insulating material of which is fibrous.

Underground conductors cost from four to five times as much as overhead conductors, which is a matter to be carefully borne in mind.

The manner of laying cables is simple. It is first necessary to draw a rope through the duct to be occupied. To do this, rods about three feet in length are used, having brass male and female screw attachments, one at each end. The first rod is inserted in one end of the duct; then another is screwed into it and pushed forward, and this process is continued until the first rod emerges into the manhole at the other end and you have an unbroken line of connecting rods through the duct. A rope is then attached to the last rod, and, as the rods are pulled forward and unscrewed in the manhole at the distant end, the rope is gradually drawn through. Unless a large number are to be drawn into a single duct, they can be drawn by hand without any special machinery. If, however, it is desirable to draw in as many, at one time, as the duct will hold, it is necessary to use a winch or windlass, or, in lieu of either, a snatchblock with a rope and tackle, and enough men to pull the mass. Great care should be observed not to allow the cables to twist in the duct, as, if this occurs, it is next to impossible to withdraw any given conductor thereafter without removing all conductors in the duct. In cutting the cables to fit given sections, about 12 feet should be allowed for slack between manholes, for racking around the sides of manholes and for metallic joints. The cost varies considerably. To draw in two cables in a duct would cost in the neighborhood of from 2½ to 3 cents per foot of cable; but to draw in four or six, or even eight, as has frequently been done, the cost diminishes and will not average over two cents per foot or even less, assuming that the men in charge have had experience and understand their work thoroughly.

The proper joining of cables is a matter of paramount importance. Unless the joints are made by an experienced person, it is almost impossible to secure a joint which will give the same insulation resistance as the cable itself, and yet, unless the joints are so made, the object of securing immensely high insulation in the cables proper is entirely defeated and a large proportion of the original investment practically wasted.

* Read before the National Electric Light Association, at Buffalo, February, 1892.

The New York Subway Company, in its early inception, framed a set of rules governing the operation of underground conduits. Among them is one which has always challenged my admiration, and the man who framed it either built wiser than he knew, or was a remarkably gifted person. This rule at first was considered absurd and impossible of compliance, but today I think I am safe in saying that every electric light company governed by it will acknowledge its wisdom and admit that, by having enforced a high standard of insulation from the very outset, a large amount of subsequent experiment and waste of money has been avoided. I quote the rule:

"Section 4. Electromotive Force.—All conductors drawn into and operated in the conduits, and intended to convey currents of an electromotive force exceeding 100 volts, shall have at the temperature of 75 degrees Fahrenheit an initial insulation resistance of not less than 15 megohms per mile per 100 volts electromotive force of current in the circuit. Whenever the insulation resistance of a conductor as aforesaid shall prove to be less than five megohms per mile per 100 volts, the use of that conductor shall at once cease, unless the actual electromotive force in its circuit be reduced so as to re-establish the foregoing ratio."

You will observe that the initial tests of cables laid by any of the companies in New York City must show an initial insulation resistance of not less than 15 megohms per mile per 100 volts of current used. This means that, with an alternating current of 1,000 volts, the cable must show, before the current is turned into it, to have an insulation resistance of not less than 150 megohms per mile; with an arc circuit of 2,500 or 3,000 volts, or even 4,000 volts, initial insulation resistance must not be less than 375 megohms, 450 megohms and 600 megohms, respectively. Taken into consideration with the fact that, on an ordinarily humid day, overhead circuits will not show an insulation resistance of more than from 200,000 to 500,000 ohms per mile, the above requirements seem altogether impossible of attainment, and to be ideal rather than practical, but this is not the case. On the contrary, it is rare, indeed, that the initial tests of cables laid in New York City do not show from three to four times the initial insulation resistance required by the rule, and, of the hundreds of miles of cable actually in operation at the present time, and which have been in operation from two to three years, and with which I am personally familiar, I do not believe that there is one that will not show, under like conditions, nearly, if not quite, the same high degree of insulation as when the original test was made.

The first cable laid by the Manhattan Electric Light Company on Broadway was insulated with rubber compound and the joints were made by contract, on the representation of the contractor that his men were professional jointers. After the cable was connected throughout, a test showed less than a megohm of insulation per mile, and this bad condition of things was quickly shown to be in the joints; every one of them had to be cut out, and our lesson was well learned. Since that time we have never allowed any but our own men, specially trained and educated for the purpose, to make joints on rubber compound cables. I once wrote a gentleman regarding joints, that, in making each and every one of the thousands of joints in use, we have observed in every case the same care and precaution in making them as is observed by the Atlantic Cable Company in repairing breaks in mid-ocean, where, in such cases, it used to be the custom, before they maintained their own ships, to charter or equip a vessel to reach the locality of the break, the cost of which ran anywhere from $40,000 to $60,000, and where this whole sum was dependent upon the making of one first class joint. This may sound like an exaggeration, but, nevertheless, I can assure you that our extraordinary precaution has saved us an unknown but large amount of trouble and, on that account, our almost total immunity from interruption is largely due. The cost of joints will run from $2 to $3 apiece, and any manufacturer can give proper directions how to make them and what to use, both as to metallic contact and insulation, but, in the case of the rubber compound cables, the difficulty lies more with the man than with the method. Men whose hands are naturally moist cannot make a good joint, *i. e.*, a joint which will test "infinity."

We are required to test all underground circuits at least once per week. For this purpose a portable reflecting galvanometer is used. Where the cables enter the station a test room, free from the jar of the building, is usually provided in which to set up the instruments; but, in cases where the cables are reached from the station by overhead wires, it is customary to rent a quiet room adjacent to the junction pole and connect by a well insulated "lead" for permanent use. The total insulation of a circuit, with all converters or arc lamps connected, will generally fall below the requirements of the rule above quoted, but, unless it is shown to be less than say one megohm per mile of cable, its condition, as a "completely connected circuit," is usually accepted. But, as a general rule, when the insulation falls below this standard, what are termed "ex-converter" and "ex-lamp" tests are called for. These require, in the case of incandescent circuits, that every converter installation be cut out, the cable ends freed from all contact, and test of cables only be made to ascertain their exact condition. The arc circuits are similarly treated by disconnecting all lamps and switches. Unless the results of such tests come within the limit prescribed by the rule, the circuits are not allowed to be operated until the defect has been removed and the insulation brought back to the required standard. Fortunately, defects are rare, and tests of this character are not now called for with sufficient frequency to prove burdensome.

House connections are built by the Subway Company at the expense of the electric light companies; but the Subway Company claims not to relinquish ownership therein and will not allow their joint use by two or more companies, except by special arrangement. The cost of house connections in New York City is appalling to the man of exclusively overhead experience.

Fortunately, it often happens that one house connection will serve for two or three different installations, and, in this way, the average cost per installation or per arc lamp is very largely reduced. For instance: In the fall of 1890 our arc lamp connections cost us, on an average, only $43; in the spring of 1891, an average of about $30; the ratio of new connections to new installations or lamps being as one is to two. In other words, for 100 installations or lamps we were required to make but 50 house connections. This ratio could be largely and safely reduced were we allowed by the authorities to use more than 100 feet of overhead wire with each underground connection.

It is a fact worth knowing that the underground service is more reliable than that of the overhead. Storms, blizzards, sleet and wet snow have little or no effect upon it, and neither has lightning, where the circuits are entirely underground. In consequence, cases of interruption are rare; crosses never occur; grounds but seldom, and open circuits are unknown, except when a break occurs at a lamp or a switch.

The number of "burn-outs" in the subways is small, and thus far, after three years' experience, not a single instance of burn-out has occurred in our "rubber" compound cables that has not been directly attributable to some imperfection of manufacture, which originally escaped detection, or to mechanical injury after the cables were laid. And these have not amounted to more than 10 or 12 all told. We have, however, had several instances with the "fibrous" compound, but whether due to accidental abrasion of the lead covering, which is fatal to that form of insulation, or to some inherent defect, we were unable to determine, as the intense heat of the escaping current destroyed all evidence in each case.

During the first year of our experience we suffered considerably from mechanical injuries caused by the carelessness of employes of other companies having common access to the manholes with ourselves, and I presume our own men were equally culpable as regards the property of our neighbors, but the common experience of the companies suggested greater care and consideration upon the part of all, and, by carefully stowing the cables away upon racks built along the sides of the manholes, mechanical injuries have now become exceedingly rare.

On wet nights we have an occasional case of trouble in a leaky switch box, or at an exposed joint, where the wire running to the lamp is connected with the cable. These joints were at first covered with ordinary tape, but after a few months' exposure the tape would invariably leak under the high pressure and sometimes convey the current to the lead covering and result in a burn-out.

In the case of rubber compound cables, we now simply cut back the lead a few inches, strip off the taping, make an ordinary metallic joint, and then slide over the bare metal a floor insulator, open at both ends, and standing upright so as to allow the rain to run through the lower end; the insulator resting upon the rubber compound, not upon the lead covering of the cable. This, of course, refers only to lamps where switch boxes cannot be used, such, for instance, as city lamps. Where fibrous cables are used, a regular insulating joint of pure rubber is made, connecting to a short piece of specially insulated wire. The joint is immersed in boiling hot paraffine and the specially insulated wire is then connected in the ordinary way to the wire running to the lamp. This is done to protect the insulation of the cable from moisture and also to facilitate connecting and disconnecting with the lamp, which the regulation tests frequently render necessary.

In laying cables it has been found desirable to place both "legs" of incandescent circuits in the same duct. When they are separated into different ducts great loss results from self-induction.

The use of the subways makes it possible to employ much heavier single conductors than could be used overhead. There are in some of the ducts conductors having nearly, if not quite, 500,000 circular mils area, and such sizes as No. 00 and No. 000 are quite common. The conductor being composed of small wires stranded affords sufficient flexibility for all purposes; but in sizes up to and including No. 2 B. and S., the conductor is generally solid.

In the matter of public safety, the records of the past three years show but one death to have occurred from current conducted underground, and that particular case occurred on top of a city lamp post on a wet night, the victim neglecting to use his gloves. Prior to 1891, deaths caused by shock from overhead wires occurred with considerable frequency—sufficiently so to arouse great public excitement and hasten the burial of the wires underground. But it is fair to state that more than nine-tenths of all the accidents were primarily due to the inferior character of the overhead construction and the extraordinary multiplicity of wires of all kinds in the streets.

A good system of underground conduits fairly covering the electric lighting territory of a large city will, in my opinion, cost on an average from $2,500 to $3,000 per mile per duct, but, in the case of a single duct in a trench, the latter figure is likely to be exceeded, depending largely upon the character of the digging and the engineering difficulties to be overcome. For the purpose of comparison, however, let us assume $3,000 to be the cost of one mile of distributing duct and then consider the cost of one mile of construction for one arc and one incandescent circuit, by both underground and overhead methods, as follows:

UNDERGROUND.	
Duct	$3,000 00
Eleven thousand feet No. 4 cable at 20 cents, laid	2,200 00
Eleven thousand feet No. 2 cable at 30 cents, laid	3,300 00
Forty house connections at $75	3,000 00
Total	$11,500 00

OVERHEAD.	
Fifty poles prepared and set at $12	$600 00
Eleven thousand feet No. 4 wire, at 4½ cents	495 00
Eleven thousand feet No. 2 wire, at 7¼ cents	797 50
Forty house connections	480 00
Total	$2,372 50

Hence, from these figures, it must be assumed that the initial investment for an underground system will exceed, by about five times, the cost of an overhead

system, and the fixed charges on this very expensive feature of investment in a central station plant must be correspondingly increased.

But in New York City, as before stated, the underground conduits are owned by a subway company, who have an exclusive franchise and who lease their ducts to the various electric light companies upon the following schedule of rentals:

Distributing ducts		$1,000	per mile,	per annum.
Trunk ducts, 3	in.	900	"	"
2½	"	800	"	"
2	"	700	"	"
1½	"	550	"	"

These rates have the effect of increasing the usual and ordinary expenses of a central station enormously, and, although some overhead wires are still in service, and our field of operation is almost wholly confined to the more important streets and avenues, *the amount of the duct rental already equals the combined cost of coal, water, oil, waste, and the salaries of chief engineer, engineers, firemen, coal handlers, boiler cleaner, and oilers employed in the engine department.*

WAVE MOTION MODEL.

As a teacher of physics I have always experienced considerable difficulty in giving to elementary students of sound a clear conception of the motion of the air in organ pipes when sounding. In Weinhold's "Physics" a method is shown in which a series of sinuous lines, drawn on a sheet of paper, exhibit this motion when drawn across a narrow slit, but the difficulty attending the drawing of these lines has, I imagine, precluded its general adoption for class purposes. It struck me that it ought to be possible to draw a series of eccentric circles upon a disk in such a way that, when rotated, the motion of the intercepted lines, as seen through a narrow radial slit, should correctly represent this motion. This, of course, is done for

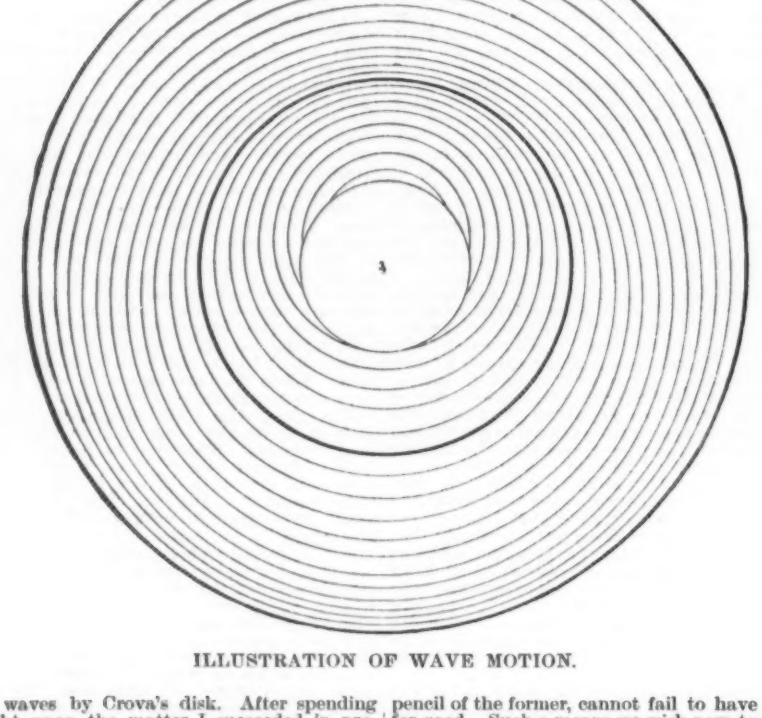
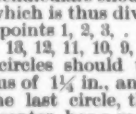


ILLUSTRATION OF WAVE MOTION.

progressive waves by Crova's disk. After spending some thought upon the matter I succeeded in producing such a disk, a copy of which I inclose. It has given such satisfaction that I have been advised by several scientific friends to send a description of the method to you for publication, for the benefit of teachers and students generally.

In the following description I have given the dimensions which I myself employ in describing these disks, but they can of course be varied at will.

A piece of stout cardboard should be taken about a foot square. A line AB, ¾ in. in length, should then



be drawn near the center and a circle described about it, half of which should then be divided as shown into 12 equal parts. Perpendiculars should then be dropped upon the line AB, which is thus divided in harmonical progression in the points 1, 2, 3, ... 13. With the points 1, 2, 3, ... 13, 12, 11, 10, 9, 8, 7 successively as centers, a series of circles should then be drawn, beginning with a radius of 1¼ in., and increasing it each time by $\frac{1}{16}$ in. The last circle, therefore, described with the point 7 as center, has a radius of $4\frac{5}{8}$ in. The two circles described with the point 7 as center, since they represent nodes, should be drawn rather thicker than the others to distinguish them.

The disk is now complete. It should be cut circular in shape and mounted to rotate upon a pin struck through the point 7. If it now be examined by means of a narrow radial slit extending across the marked portion of the disk, the short lines intercepted will, by their pendulum-like motions, represent the motion of the air particles in a closed organ pipe giving its first overtone. When the slit is shortened so as to show only the portion of the disk between the two nodal lines, the vibration of a rod clamped at both ends will be represented; while the outer half of the latter length of slit will represent similarly a closed organ pipe giving its fundamental note. In this way, by restricting the slit to various parts of the disk, various vibrating rods of metal and organ pipes can be represented.

The disks thus produced I have had very satisfactorily lithographed for students' use.

Should any of your readers be desirous of obtaining further information, I shall be happy to oblige them.

F. CHESHIRE.

P. S.—In the drawing of the disk given the center has been filled up by broken circles. As thus drawn the inner circle may with advantage be blackened over.—*Nature.*

A NEW USE FOR THE OPTICAL LANTERN.

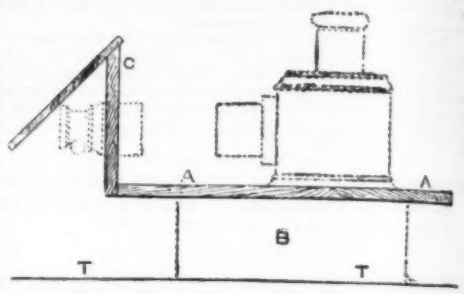
WITH the increase of schools of art all over the country a knowledge of drawing has become far more common among us than it was twenty or thirty years ago. This is indeed a subject for congratulation, for the practice of art, different from many other pursuits, confers benefit and pleasure upon others besides its professor. Since, too, the invention of several photo-mechanical processes by which drawings can be readily transformed into typographic blocks without the intervention of the engraver, there has been a demand for drawings in black and white such as never existed before; so that all around us we see schools arising which profess to devote themselves to the new branch of graphic art, and pupils eagerly availing themselves of the proffered instruction. We think, then, that any means which promise a still closer union between the photographer and the draughtsman, and which may tempt the latter to adopt the pencil of the former, cannot fail to have an influence for good. Such a means we wish now to place before our readers, and, although we cannot claim any great originality for the suggestion, we may at least say that it is a new application of an old idea.

It came about in this way. Some time ago we were wishful to obtain some photo-mechanical blocks from certain lantern slides we had at hand. The half tone processes of the Meisenbach type were obviously out of the question, for the printing had to be done on a quick rotary machine. It was therefore determined that they should be drawn in line on card in the blackest of inks, photographed, transferred to zinc, and etched in the usual manner. But when we came to make the necessary enlarged drawings from the slides, we found that the work was extremely slow and laborious, although we employed proportional compasses and other labor-saving devices. It was then suggested that the slides should be severally placed in a lantern, and that the resulting enlarged image, received upon a piece of card, should be outlined direct in pencil. This we did, but found the work extremely fatiguing, for the cardboard upon which we penciled the lines was necessarily in a strictly vertical position, and the attitude assumed was so cramped that a frequent rest was demanded.

It was now suggested that things might be much improved if the enlarged image, instead of being projected horizontally, were thrown down upon a table, at which the worker might sit with some degree of comfort. The hint was quickly acted on, and by the same evening we had constructed a rough and ready enlarging apparatus for draughtsmen, which has since been constantly in use, and which we would not readily part with. It is simply an application of the *camera lucida* principle, which has so long been in use for the drawing of microscopic objects, to the ordinary mineral oil optical lantern, only that, instead of using a prism, we make use of a common mirror.

The apparatus consists of a base board about seven inches in width, with a ledge at each side, leaving in the center sufficient space for the lantern to be moved to and fro, while at the same time the ledges cause the image cast to be always central. But the relation of parts will be best understood by reference to the accompanying sectional drawing.

AA is the base board, made out of inch deal, with a ledge on each side as already stated. It is about seven inches in width and three feet in length, and while in use it is supported on a (lantern) box, B, laid on its side on the table, TT. At one end of this base board is an upright, C, of the same width (seven inches), pierced in the center with a four inch hole, so as to carry the front of the lens tube, which is separated from the lantern body by a space which varies with the amount of enlargement or reduction which may be required. At the top, this vertical board is beveled to an angle of 45°, and by means of wooden buttons a piece of looking glass, face downward, is fixed at that



angle. This glass is large enough to cover the lens front, so that the image of the picture on the stage is intercepted and cast upon the table below, upon which a sheet of cardboard is placed to receive it. A piece of ordinary looking glass is employed—in our case we actually use a hand toilet glass—and although theoretically such a glass, not silvered on the surface, should cast a double image, in practice it is found that no secondary image is perceptible. Indeed, so free is the reflection given from this difficulty that the arrangement might with advantage be employed for making reversed negatives.

A lantern can be used in this way by daylight, provided that the window blind is pulled down, so that the picture thrown upon the cardboard is not eclipsed by the brighter light. There is, indeed, an advantage in working under such conditions, for the lines of the picture may be traced over in pencil, while, at the same time, the artist can watch the growth of his own work. There is also an advantage in shutting off the lantern light every now and then, so that progress may be reported the more effectually. It is obvious that the lantern employed in this way will give a reduced image as well as one which is larger than the original. But, in this case, it will be found necessary either to reduce the size of the support upon which the base board stands or to raise the cardboard upon which the image is cast. The apparatus as shown is, of course, but a makeshift, and a far more perfect contrivance can be readily constructed by any one with a little ingenuity in his composition. Such an improved instrument would comprise a mechanical movement for altering the height of the lantern, as well as a rack-work for moving it from and toward the front lens. There are many other points which will doubtless be suggested by those who care to give time and thought to the matter. We place the idea before our readers in a roughly hewn state, and will leave them to cut down its angles and polish it up generally according to their individual tastes.

We need hardly point out that with a more powerful source of light—such as the oxyhydrogen light—the lantern can be used for tracing pictures of far larger size. In this form it should be most useful to artists for making rough sketches upon canvas or paper. We have also often suggested that scene painters should call in its aid to help them in sketching out their designs in charcoal, instead of squaring both drawing and canvas in the usual manner.—*Photo. News.*

THE VIKING SHIP.

ONE of the most interesting relics of antiquity I have seen during my travels abroad is the Norse-Viking ship, dating from the iron age. It was discovered in a mound at Gokstad in 1880, and is now kept in the archæological department of the University of Christiania.

About 100 miles southwest of the city of Christiania, on the west side of Christiania fjord, near its mouth, is situated the small Norwegian village of Gokstad. Here, near the sea, is a large mound, which has been known for centuries as the "Kongshaugen" (the King's Mound), where, according to tradition, a king was buried, with all his treasures. Tradition also informs us that in the olden times the grave was desecrated and the treasures stolen by marauders.

On the strength of these traditions and the appearance of the mound, which had evidently been made by human hands, the Norwegian Antiquarian Society, under the Presidency of Prof. Nicolaysen, determined in 1880 to excavate the mound and make a thorough examination of its contents. As the work went on it soon became evident that a discovery of unusual interest was being made, as the mound was found to contain a large ship in an excellent state of preservation.

Immediately surrounding the vessel was a layer of potter's clay three and a half feet in thickness, to the impermeability of which is attributed its wonderful preservation of over 1,000 years.

As the excavation advanced, it became evident that further discoveries were being made, for within the vessel was found a tomb containing the remains of a human being. As the greatest care was exercised in the examination, it occupied several months. When completed, the ship and its contents were removed to Christiania, where the Norse-Viking ship of the ninth century may be studied to great advantage.

The vessel's length of keel is 102 feet 9 inches, and its width in the middle is 17 feet. It is remarkably sharp and has a fast run. Its length is very much greater in proportion to its breadth than is found in the modern coasting vessels in Norway.

The Viking ship is "clinch built," of oak, 16 strakes high. There are 17 frames, placed three feet apart, on the keel. They run to the eleventh strake, and are there fastened and joined to the ship's side by knees. It is remarkable that the frames are not fastened to the keel, but bound to the planking with soft roots of trees through holes in clamps, which are cut in the plank itself. The garboard strake is fastened to the keel with iron bolts, the upper strake with treenails through the timbers. The seams are calked with threads of yarn spun of cow's hair.

The ship has been made both for sailing and rowing. Remains of the mast, spars and yards were found in the vessel. In the third strake from above are seen 32 holes, openings for as many oars, 16 on each side. Oars were also found in the vessel.

Rows of shields, made of carved wood and skins, hung along the bulwarks. Most of these crumbled to pieces during the excavation. Four, however, remain in a fair state of preservation.

In the middle of the ship rise blocks of timber placed against a roof tree. The end walls were made of planks. This is the sepulchral chamber. The timber was covered with birch bark and also with clay. Inside this chamber, on a bed, were found the remains of the buried chief. They were those of a very tall, powerfully built, elderly man. In this chamber were also found several interesting ornaments in gilt, bronze, lead, iron, wooden carvings, wooden cups and plates, specimens of yarn spun of cows' hair, soft roots of trees and ropes made of thin bark, pieces of homespun canvas with red stripes and feathers, gold-wrought silk, dark woolen stuffs, a leather purse, etc.

A large hole is seen in the starboard side of the ship under the sepulchral chamber. Here the robbers had entered at an early time when the exact spot of the burial chamber could be located and plundered the sacred tomb. The "sagas" make frequent mention of similar cases of robbery in the dark ages.

In the ship were also found fragments of three smaller boats, oars, iron chains, copper kettles, cooking utensils, wooden spades, wooden carvings, etc.

The ship is supposed to have been an open vessel, although it could have been covered with timber or canvas if desired. It has been calculated that the vessel had a crew of forty hands, and that its carrying capacity was about thirty tons.

The rudder is on the starboard quarter in its original position. This fitting of the rudder on the side of the vessel is everywhere regarded as the ancient method. From it we have obtained our word "starboard." It was not until the latter part of the Middle Ages that rudders were placed on the stern post. In the mound along both sides of the vessel were found the remains of twelve horses and six dogs. They had evidently been killed and buried alongside their master's ship, as was the custom, in order that he might have their services in the happy hunting grounds, not unlike the methods of some of our American aborigines.

The manner of burial in Norway during the latter part of the iron age was as follows: When a chief died a place near the sea, fjord or lake was chosen for his sepulcher. Here his ship was drawn up from the water by his own horses and embedded in potter's clay, the stern toward the sea. A sepulchral chamber was next built in the middle of the ship, astern the mast, which was cut off level with the top of the chamber. The dead chief's body or—in case cremation were practiced, as it was sometimes—his ashes in an urn was placed in the center of the chamber in his own bed. He was dressed in his best clothes, displaying his rank. His weapons and many of his valuable possessions was placed by his side. The sepulchral chamber was then covered with birch bark and clay, to preserve the wood. The chieftain's horses and dogs were killed and placed alongside the ship. The whole vessel was next covered, inside as well as outside, with potter's clay; then a layer of moss and twigs, upon which was built the mound. Many of these burial mounds may be seen in different parts of Norway. Several have been excavated and human remains found, but the vessel now at Christiania, discovered in 1880, at Gokstad, is the best preserved and most perfect Viking ship in existence.—*Chronicle, San Francisco.*

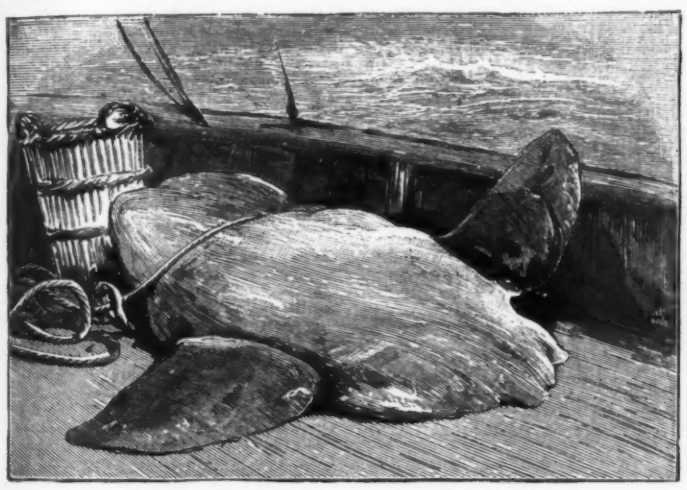
WEST COAST OF IRELAND FISHERIES.

REV. W. S. GREEN, in the *Graphic*, says these western coasts so abound with fish that from time immemorial they have been visited by fleets from Holland, France, Sweden, as well as those belonging to the east of Ireland and England. Two hundred years ago the West of Ireland fisheries were considered of such value that small, now almost deserted, creeks were garrisoned with soldiers for their protection, and large sums were paid and treaties made for the right to fish. Nowadays, with the exception of the spring mackerel fishery, which is Ireland's great specialty, and with which no other country can compete, foreign fleets do not resort to these fisheries at all. What has caused this change? Have the fish gone away? The first question is easily answered. Steam communication has brought into competition other sources of supply, and completely revolutionized the fish trade.

The second question is not so easily answered. It was to test this latter question that an enterprising attempt was made during the last two years by the Royal Dublin Society, assisted by government. An expedition was fitted out to examine practically all the fishing grounds off the West of Ireland, and report on them.

In the s.s. Fingal, in 1890, and the s.s. Harlequin, in the spring of 1891, we visited nearly every navigable channel among the islands and creeks of the west coast, and fished seaward fifty miles from land into the great depths of the ocean. We met the people of the coast engaged in their various maritime pursuits—fishing, kelp burning, and trading along the coast in their hookers. The larger hookers, of which there are many, live by trading; good freights being obtainable for comparatively short voyages. Fishing is mostly prosecuted in canoes made of canvas, of the very best model, and for coast fishing no craft could be safer and more convenient when in skillful hands, and often, in proportion to the expense, make more money than the large vessels.

Besides the maritime industries I have referred to, the kelp trade gives employment to hundreds of people. When there are storms in spring, the kelp burners are happy; for the great brown fronds and stems of seaweed are torn from submerged rocks and thrown on the shore. Otherwise the weed has to be cut. It is dried on the rocks and shingle beaches, stacked in heaps, and when enough is collected the burning begins. A kiln is made of a few bowlders placed so as to form a trench, a fire of turf is lighted, the dry weed placed layer after layer on the fire, and when the ash, forming a hard slag, attains the thickness of about a foot, the fire is extinguished, the slag, or kelp, as it is now called, is allowed to cool, broken into lumps, and exported, in large vessels which call for it, to chemical works in Scotland, where iodine and other valuable products are prepared from it. The long lines of smoke from the kelp kilns form a characteristic feature of every west coast landscape.



A SUNFISH ON DECK.

A KELP KILN, CONNEMARA.

LICE AND GAPE CURE.

DR. SPAULDING says: "I promised you a specific against all manner of mischievous insects that infest the poultry house and nests. Something safer and surer and more convenient than fumigation or whitewash, and so speedy and simple that when once employed the poultryman fastens his hold upon it as an entirely satisfactory specific. I take for 600 square feet of house room one-half bushel of lime, place it in a box in the open air and sprinkle with water and secure complete pulverization; in other words, slake the lime perfectly, let it get entirely cool, and then to this half bushel of pulverized lime add ten pounds of sulphur and one ounce fluid carbolic acid, and stir the whole with a stick until well mixed. Then it can be safely handled with the hand. After sweeping out the hen house drive out all the birds, close all the doors and windows and begin at the further end and walk backward, scattering the mixture freely all over the floor and through the air on to the perches and into the nests everywhere thoroughly, and it is difficult to conceive how dense the cloud of medicated dust that will hang suspended throughout the whole interior of the house. Gradually it settles everywhere, in every crack and crevice, and wherever it reaches a hen louse or other insect he retires from business permanently. It purifies as if by fire. I think there is nothing on earth equal to it for thoroughness, cheapness and expedition. If the chicks have roup, leave them in the house and let them stem the storm, it will not kill nor hurt them, but the sneezing will be terrific and every particle of mucus that has accumulated in the air passages and throat will be expelled and the medicated dust will reach every portion of the membrane and cure it too. But gapes, that is the deadliest shot on gapes one could imagine. It kills the worms in the air passages and makes the chick cough them up, and so cures the case at once. No horsehairs and feathers dipped in turpentine, nor tobacco fumigations, all of which will endanger the life of the chicks, but this medication is not only safer and cheaper, but surer; indeed, it is a positive specific. Now, Mr. Editor, when you can publish to the world from positive experience a remedy that is entirely harmless and at the same time a specific against lice and gapes, you have, or should have, an influence in the poultry yards of the United States."

LICE IN A NUTSHELL.

1. When chicks droop and appear sick without cause, especially in summer, look for lice, not the little red mites, but the *large gray body lice* on the heads and necks.
2. If you find them, use a few drops of grease of any kind. A teaspoonful of oil of pennyroyal to a cup of lard is excellent.
3. Look under the wings for the red lice, but use only a *few drops* of the lard.
4. Never grease the bodies of chicks unless lightly, as grease will often kill them.
5. Never use kerosene on chicks, unless it be a teaspoonful of kerosene to a teacup of lard, as it is irritating.
6. Crude petroleum is always excellent, and serves as a liniment, but mix it with twice its quantity of lard.
7. Keep the dust bath always ready. Use dry dirt or sifted coal ashes. Add carbolate of lime, Persian insect powder or oil of pennyroyal to the dirt.
8. To rid the house of lice saturate with kerosene (coal oil) or the kerosene emulsion, *everywhere*—floor, walls, roosts, yards, roof, inside and outside, and repeat often.
9. Dust insect powder in the feathers, and be sure it is fresh and good for little chicks.
10. Put insect powder and tobacco dust in the nests. Never pour grease in the nests. Clean them out every week.
11. Even when no lice may be present use the sprinkler of kerosene at least once a week; and keep the roosts always saturated.
12. No matter how clean things may appear, look for the large lice on the heads, throats and vents.
13. Lice abound both in winter and summer, but more especially in summer.
14. One-half the chicks and young turkeys die from lice. Chicks or turkeys with hens or turkey hens always have lice (either the mites or large lice). Remember that.
15. Carbolate of lime is the cheapest powder to use for dusting over the floors and walls.
16. Always aim to get the solutions or powders into the cracks and crevices.
17. The easiest and best way to whitewash is with a force pump. They are now made to force water from a bucket. F. Schwarz, Fairfield, Ct., makes a cheap sprayer.
18. When your chicks have bowel disease, look for the big lice.
19. No mites need be present where plenty of coal oil and carbolic acid are used.
20. Lice means work. Repeat these precautions and remedies frequently.
21. The sleepy disease always means lice, especially on the heads and necks.
22. Chicks are hatched with no lice. The lice on them come from the hens.
23. To make the kerosene emulsion cut up (slice) half a pound of hard soap in half a gallon of water. When the water boils and the soap is dissolved remove it from the fire and add one gallon of kerosene (coal oil). Agitate it with a paddle for ten minutes and a creamy mass will be formed, which becomes a jelly when cold. The mixture is always made by using twice as much coal oil as water. When you have finished agitating the mixture add ten gallons of water or soapsuds from the family washing, and you have the cheapest and best mixture that can be made.
24. You can make an emulsion in the same manner as the above with crude carbolic acid, crude petroleum, coal oil or fish oil.
25. The sprayer will force the mixture in the shape of a fine spray. See No. 17 above.
26. Air-slaked lime, freely dusted everywhere, is cheap, and will destroy lice, gapes and roup.
27. The kerosene emulsion, after it is diluted, as mentioned in No. 23, may be used as a bath for fowls, dogs, cats or anything that is infested with lice or fleas.
28. The odor of oil of pennyroyal is always disagreeable to vermin.
29. Use only the fresh Dalmatian insect powder which comes in sealed tin cans. It costs about seventy-five cents per pound. The California buhach is equally as efficacious.—*Fanciers' Journal.*

HOW TO GET ON AND OFF A CAR.

THOUSANDS of women ride in horse cars in New York every day, of whom ninety-nine hundredths, or nine hundred and ninety-nine in a thousand, are in a state of next to complete ignorance of the scientific laws which dictate the methods of mounting and descending in safety, and threaten disaster upon those who violate them. As a rule the cars are stopped and started properly, so that a woman can step on or off as though she were on her own staircase. But occasionally the horses will start a moment too soon or the impatient female will attempt to step into the street while the car is still moving, and then—there comes calamity, perhaps humiliating and embarrassing, and always dangerous. The *Sun* presents here a few luminous and important chapters upon the art of avoiding accidents in connection with the use of street cars. If they are studied with intelligence and thereafter treated with the unvaried respect due to their intrinsic soundness, it is safe to say that there will be an end to a certain class of accidents to life and limb which has accompanied the use of street cars from the beginning. Also skirts that would otherwise be soiled or torn will live to die of old age, and bundles that would have been scattered over the streets by the overthrow of their fair bearers will reach home intact and clean.

The point is to always grasp the handle toward the front, slightly facing in the same direction. If you do

THE WAY TO GET ON.

thus you are safe. You are like a ship with an anchor to windward. Even if the car starts suddenly out of time, your hold, being in the proper place, will sustain you in making a quick step forward, and so enable you to board safely and easily and laugh at the fault of the conductor.

It is very easy to board a car properly, yet for some reason or other the majority of women will do like this:

HOW NOT TO GET ON.

If the car starts with you holding on by the rear handle, as shown in the cut immediately above, you are lost to the extent shown below, not to say further:

RESULT OF GETTING ON BY REAR HANDLE.

There are experts who can take such liberties with horse cars, but they are citizens with whom the art of catching on is a necessary part of their profession. As a rule, they are of the male sex and under fifteen years of age. For example:

THE INDIVIDUAL WHO CAN TAKE LIBERTIES.

The girl who knows a thing or two regarding the law of gravitation and the conservation and correlation of forces, and comprehends their practical application in connection with horse cars, will get off in the manner depicted below and never bite the dust.

HOW TO GET OFF.

As in getting on, she seizes the front handle, slightly facing the horses. Don't be afraid to face too full to the front; the fuller, perhaps, the better. Then even if the car starts, a quick step or two can easily be taken with it, and when once having got your footing on the ground you can let go of the handle and walk away. The girl last pictured may venture to step off while the car is still in gentle motion.

But if in our fair shopper's mind there is a total blank where the law of inertia should be written down, she may ignorantly or carelessly attempt to get off according to this plan.

HOW NOT TO GET OFF.

If she does this and the car starts, or if she impatiently puts her foot to the ground before it has stopped, the consequences in either case will be like this:

SOMETHING LIKE THE CONSEQUENCES.

Don't forget any of these maxims. Observe them always, and one danger incident to civilization will be removed.—*N. Y. Sun.*

SCIENTIFIC EATING.

Go down into Hudson Street any day and you will see a lot of children, and very likely a handful of grown people, gazing with curious eyes into the lower windows and through the glass doors of the big brick block that stands at the corner of Charlton Street. Every few minutes these gazers will give way to let some woman or half grown child go in with a tin pail or a covered dish, presently to come out with the same dish carried with the most elaborate care. These sharp, watching eyes see within, at one side of the long light room, a desk with a slender blond young woman writing at it; on the other, an oaken dresser with plenty of dark blue plates and cups ranged upon it, and back of them in the center, a light gas range, with closely covered graniteware kettles steaming upon it. Still back, partly hidden by a wide Japanese screen, is a dim vista of big steam kettles, curious ovens made of asbestos and tin and fired with small kerosene lamps, with white aproned priestesses ministering in mysterious rites. On the walls are big charts with bars of red and blue and yellow across them, and on a wide table is a great pile of wooden blocks, big and little, painted in the same colors as the charts.

What all these may be, the children gazing in the window haven't the slightest idea, but what they do understand is the granite kettles on the range. Every time the lid of one of these is lifted there comes up a puff of steam that lifts along the air and tickles and tantalizes the inquisitive noses outside with savory smells that are not to be misunderstood. There are stews in those kettles, and chowders, and other good things, that is certain, and in the queer ovens are puddings and baked beans and such other things as go into ovens and come out wearing brown coats. Another thing that these gazers understand fully as well as those who come and go with dishes is that although none of these good things is given away, yet a pint or a pound of anything in the establishment can be bought for from 5 to 15 cents.

This is a new enterprise, not only for Charlton and Hudson Streets, but for New York City as well. It is the offshoot of that famous Boston philanthropy, the New England Kitchen, and is called by the same name. It has just been established. Its object is philanthropic, but not purely charitable, because food is not given away except in unusual cases, and with brisk patronage it will entirely pay its own expenses, as the Boston establishment does. Neither is it a business scheme, because nobody in connection with it wants to make money out of it. As might be expected of any philanthropic enterprise originating in Boston, it is largely educative, and aims to educate by that most irresistible of all appeals, the appeal to the palate. Its aim is to diffuse among wage-earning persons with moderate incomes a knowledge of the possibilities in the common and cheaper food materials. These, which through ignorance are so often either wasted or made into indigestible compounds, may, with a little intelligent understanding on the part of the cook, be converted into good, tasteful food, of standard nutritive value.

The Boston New England Kitchen, with this avowed reason for being, was started in 1890 under the direction of such men and women as Edward Atkinson, Mrs. Ellen M. Richards, Instructor of Sanitary Chemistry in the Institute of Technology in Boston; Mrs. Mary H. Abell, and others. It made and offered for sale, at about the cost of production, nutritious soups and stews, beef tea, pork and beans, simple puddings, wholesome bread, and other dishes in common use. In six months its financial success was a certainty. The kitchen in New York is under the same auspices and under the general supervision of Dr. Thomas Egleston, of the School of Mines, of this city. The slender blond young lady who sits at the desk is the general manager, Miss M. B. Gould, of Boston, and Miss Ellen J. Knight is the superintendent of the important end of the enterprise—the cooking. Both these young women know a wonderful number of scientific facts about food, and make a special point of telling their patrons how these foods are cooked and why they taste so remarkably good. They have a daily bill of fare, comprising such things as beef broth for invalids, beef stew, vegetable soup, fish chowder, pea soup, hominy, hash, rice pudding, and baked beans. They are careful to explain to every comer who gives the least hint of interest the important fact that in the preparation of the stews and soups none of the expensive cuts of beef is used, but only neck and shin pieces. It is the wise cook, they tell these women, who buys, not the high priced cuts of a poor quality of beef, but the cheaper cuts of the best quality. In addition, they give them a scientific insight into the chemical results of cooking by steam and by dry heat, of cooking rapidly and slowly, of the best disposition of animal and vegetable foods, and many other things, all for the asking.

"It is our aim," said Mrs. Ellen M. Richards, a few days ago, "to teach these people what good food is by giving it to them to eat. By and by they will see the difference between what they cook themselves and what we cook for them, and we shall then be able to teach them better ways. As for our methods of cookery, they are not only pleasing in their results, but they are absolutely scientific. Take our beef tea, for example, which is designed especially for the use of invalids. All the scientific knowledge I have got has gone into that. More invalids are killed by beef broth of inferior nutritive value than by the surgeon's knife. This beef broth is prepared by formula; it contains a nutritive value at least equal to that of milk, without its fat, and without sacrificing the appetizing flavor of beef. There is a proportion of gelatine from the bone; there is from 4 to 5 per cent. of solid matter, 1 per cent. of which is salt. The phosphates are from 0·01 to 0·02 per cent., and the total nitrogen is 0·04 per cent."

This can be made by any woman, with a beef shinbone and average intelligence, and it is the aim of these scientific men and women to show them how to do it, and why there is but one correct way. To aid in this work of instruction, which is gratuitous, but only offered when there is some indication of its being wanted, the big charts on the walls and the blocks of wood of various colors are brought into use. The big

blocks show the percentage composition of the human body. There are big blue blocks that stand for water, red blocks that stand for the proteids, gray blocks that stand for mineral matter, and so on through the whole list of the bodily constituents, which the charming young women in charge are able to mention easily and familiarly, but respectfully. One of the big charts on the wall explains, and diagrams by big blocks of color, the percentage composition of many of the common foods, such as apples, butter, cabbage, potatoes, milk, beef, fish, etc. It tells how much water, proteids, ash, starch, sugar, fat, etc., is to be found in each of these foods. And next to this chart hangs another, showing how much of each of these foods should be taken into the human body each day to keep up the standard of nutrition. A slight logical deduction from these two charts will teach any of the patrons of the kitchen how to buy such foods as will prove most serviceable in keeping the body well fed at the least expense.

The chart that proves most fascinating to the visitors at the kitchen is the one known as the Twenty-five Cent Chart. This chart sets forth in the same colored bars as the others the chemical composition of twenty-five cents' worth of the commonest mixed foods, such as pork and beans and brown bread, cheese and macaroni, bread and milk, eggs and bacon, and many others, showing what articles of food best supplement each other, and why these combinations are preferred to others, as furnishing the proper amount and variety of food constituents. In all that pertains to the relation of food to health these young women are able to prescribe to the patrons of the kitchen. They will tell a mother whose child has rickets, for example, that its bones need more salts and that animal food should be given to it. They will also tell a white-faced, anæmic woman that she must eat less starchy food and more fats and meat, and show her how to get the most and the best of these substances out of the food she cooks. In short, the science of feeding in all its branches is what they profess to develop, and one has only to taste the rich and dainty substances that come out of the graniteware kettles to become a believer ever afterward in the possibilities of science applied to foods by enthusiastic women from Boston.

This particular spot in the city was chosen because it was ascertained that there was here a large percentage of intelligent native born people, who are earning moderate wages. These are the people it is most desired to reach. For it is here—and in the homes of the very rich—says Mrs. Richards, that there is the greatest waste of the food products of this country, because it costs too much time or requires too much knowledge to make them into wholesome and palatable dishes.—*N. Y. Sun.*

ATOMIC WEIGHTS.

ABOUT one year ago, the Committee of Revision and Publication of the Pharmacopœia of the United States published a table of atomic weights, recalculated, after the then latest researches of leading authorities, by Prof. F. W. Clarke, chief chemist of the United States Geological Survey. The avowed object of the publication was to establish a firm basis to which all analytical data and figures in the Pharmacopœia should be referred. At the same time it was hoped that the values given in that table would be uniformly accepted by chemists, so that the inconsistencies arising from the use of different atomic weights by different chemists might be done away with. There is no question about the propriety, or even necessity, of employing the most accurately determined atomic weights in all scientific investigations. For this very reason the publication of the before mentioned table was received with approval by a number of leading authorities, such as Prof. C. R. Fresenius, of Wiesbaden; Prof. Charles F. Chandler, of Columbia College, and others. Some time afterward a critical review of the table by Profs. L. Meyer and K. Seubert appeared in the *Pharmaceutische Rundschau* (April, 1891). The principal objection of the reviewers is directed against the selection of oxygen=16 as basis of the system, which necessitates the employment of a small fraction to express the atomic weight of hydrogen (viz., 1·007, after Clarke), and slightly displaces many other figures. We shall not repeat here the arguments advanced at that time in favor of one or the other system, but shall restrict ourselves to facts or arguments which have been advanced since then having an important bearing upon the subject.

In the first place, it is well known that analytical operations in technical chemistry, mining and assaying, the alkali and acid industry, pharmaceutical or medical chemicals, aniline and gas works, sanitary and food analysis, etc. (which, after all, comprise the vast majority of chemical operations of direct and practical importance to the public), are carried on in a decidedly conservative manner, at least in so far that the gravimetric and volumetric methods of assay are based on the values which have long been adopted as standards and quoted as such in the leading analytical handbooks (Fresenius, Rose, Mohr, etc.) In some branches of industrial chemistry it is still customary to use values which are now certainly superseded by more correct ones, but custom has carried the day over scientific accuracy. In most cases, even when the more modern and more accurate figures for atomic weights were adopted, it has been customary to round off the figures at the second or first decimal, or even to round them off to whole numbers (thus: bromine, 79·76 or 79·8, or 79·95 or 80, etc.) But no matter what set of figures was used, they were all based on hydrogen = 1. And hydrogen, as the lightest gas, also formed the unit for expressing the density of gases, simple and compound.

Careful inquiry has demonstrated the fact that probably all large chemical manufactories use practically the same set of atomic weights for making their volumetric and other test solutions, and that these are practically identical with the values established by the periodical calculations and revisions of Prof. Lothar Meyer (afterward associated with Prof. K. Seubert). The introduction of a new set of values, as bases of volumetric solutions or other reagents, if it is expected to be successful, must proceed from a representative body of chemists, preferably of an international character, or it must be brought about by government ordinances, at least in those countries in which this is legally possible.

A careful study of all facts bearing upon this subject has shown that, if the Pharmacopœia were to set up a new set of standards—no matter how much more scientifically accurate—for analytical valuations, there would be a constant friction between the manufacturers and the consumers, because each would use a different measure for determining the values; and though such different measures could, by calculation, be shown to be, in most cases, approximately identical, yet such calculation would probably rarely be made, and much annoyance be caused either to the manufacturer or the purchaser. In fact, if the manufacturer and the consumer use, each, separate standards of valuation, both of them will eventually be compelled to keep two different sets of reagents or volumetric solutions on hand, to save themselves the trouble of transcalculating one set of figures into the other.

Under these circumstances, it would appear to be the wisest plan to retain for the present the atomic weights most generally in use by manufacturers and analysts throughout the world, rather than to adopt a new set starting from a different basis. An additional reason why conservatism in this matter is advisable is this, that many chemists have been for some time past, and are at present, actively engaged in revising the atomic weights of many of the elements, thus causing a constant alteration in the relative values, which will, however, eventually result in the establishment of figures trustworthy to a degree beyond the necessities of the practical analyst.

We have just received from Prof. Charles F. Chandler a new "Table of Atomic Masses," which is a new term proposed for these values, so as to do away with the too concrete term "weight," containing the figures recalculated by Prof. F. W. Clarke on the basis of publications which have appeared since the preceding revision up to October, 1891. In order to show the variations between the several sets of values, we have placed side by side the tables of—

1. L. Meyer and K. Seubert (April, 1891).
2. F. W. Clarke (December, 1890), recalculated by L. Meyer and K. Seubert upon the uniform basis of oxygen = 15·96.
3. F. W. Clarke. (This is the table published by the Committee of Revision in December, 1890.)
4. F. W. Clarke, "Table of Atomic Masses, October, 1891."

Name.	Symbol.	1. Meyer & Seubert, 1891.	2. Clarke (Dec., '90), recalculated by Meyer & Seubert.	3. Clarke (Dec., '90).	4. Clarke (Oct., '91).
Aluminum	Al	27.04	26.93	27.0	27.0
Antimony	Sb	119.6	119.7	120.0	120.0
Arsenic	As	74.9	74.81	75.0	75.0
Barium	Ba	136.9	136.7	137.0	137.0
Bismuth	Bi	208.9	208.4	208.9	208.9
Boron	B	10.9	10.97	11.0	11.0
Bromine	Br	79.76	79.75	79.95	79.95
Cadmium	Cd	111.5	111.7	112.0	112.0
Cæsium	Cs	132.7	132.6	132.9	132.9
Calcium	Ca	39.91	39.90	40.0	40.0
Carbon	C	11.97	11.97	12.0	12.0
Cerium	Ce	139.9	139.9	140.2	140.2
Chlorine	Cl	35.37	35.36	35.45	35.45
Chromium	Cr	52.0	51.97	52.1	52.1
Cobalt	Co	58.6	58.85	59.0	59.0
Columbium [1]	Cb	93.7	93.76	94.0	94.0
Copper	Cu	63.18	63.24	63 4	63.6
Didymium [2]	Di	142.0 (?)	141.9	142.3	.....
Erbium	Er	166.0 (?)	165.9	166.3	166.3
Fluorine	F	19.0	18.95	19.0	19.0
Gadolinium	Gd	.....	.....	.....	156.1
Gallium	Ga	69.9	68.83	69.0	69.0
Germanium	Ge	72.3	72.13	72.3	72.3
Glucinum [3]	Gl	9.03	8.98	9.0	9.0
Gold	Au	196.7	196.8	197.3	197.3
Hydrogen	H	1.0	1.0045	1.007	1.007
Indium	In	113.6	113.4	113.7	113.7
Iodine	I	126.53	126.53	126.85	126.85
Iridium	Ir	192.5	192.6	193.1	193.1
Iron	Fe	55.88	55.86	56.0	56.0
Lanthanum	La	138.2	137.9	138 2	138.2
Lead	Pb	206.4	206.43	206.95	206.95
Lithium	Li	7.01	7.00	7.03	7.02
Magnesium	Mg	24.3	24.24	24.3	24.3
Manganese	Mn	54.8	54.86	55.0	55.0
Mercury	Hg	199.8	199.5	200.0	200.0
Molybdenum	Mo	95.9	95.76	96.0	96.0
Neodymium [4]	Nd	.....	.....	.....	140.5
Nickel	Ni	58.6	58.55	58.7	58.7
Nitrogen	N	14.01	14.0	14.03	14.03
Osmium	Os	190.3	191.3	191.7	190.8
Oxygen	O	15.96	15.96	16.0	16.0
Palladium	Pd	106.35	106.3	106.6	106 6
Phosphorus	P	30.96	30.92	31.0	31.0
Platinum	Pt	194.3	194.5	195.0	195.0
Potassium	K	39.03	39.01	39.11	39.11
Praseodymium [4]	Pr	.....	.....	.....	143.5
Rhodium	Rh	102.9	103.24	103.5	103.0
Rubidium	Rb	85.2	85.3	85.5	85.5
Ruthenium	Ru	101.4	101.34	101.6	101.6
Samarium	Sm	(?)	149.6	150.0	150.0
Scandium	Sc	43.97	43.89	44.0	44.0
Selenium	Se	78.87	78 8	79 0	79.0
Silicon	Si	28.3	28.33	28.4	28.4
Silver	Ag	107 66	107.66	107.92	107.92
Sodium	Na	23.0	22.99	23.05	23.05
Strontium	Sr	87.3	87.4	87 6	87.6
Sulphur	S	31.98	31.98	32.06	32.06
Tantalum	Ta	182.0	182.1	182.6	182.6
Tellurium	Te	125.0	124.7	125.0	125.0
Terbium	Tb	(?)	159.1	159.5	160.0
Thallium	Tl	203.7	203.67	204.18	204.18
Thorium	Th	231.9	232.0	232.6	232.6
Thulium	Tu	.....	.....	.....	170.7
Tin	Sn	118.8	118.7	119.0	119.0
Titanium [5]	Ti	48.0	47.88	48.0	48.0
Tungsten	W	183.6	183.5	184.0	184.0
Uranium [5]	U	238.8	239.0	239.6	239.6
Vanadium	V	51.1	51.27	51.4	51.4
Ytterbium [3]	Yb	172.6	172.6	173.0	173.0
Yttrium	Yt	88.9	88.9	89.1	89.1
Zinc	Zn	65.1	65.14	65.3	65.3
Zirconium	Zr	90.4	90.37	90.6	90.6

[1] Has priority over niobium [Nb], [2] Has priority over beryllium [Be]. [4] and [5] Both formerly comprised under "Didymium" [Di]; see [2].

On examining the fourth table (October, 1891), the only differences from that issued in December, 1890, will be found to be the following:

Didymium is no longer recognized as an element. Its elementary constituents, neodymium and praseodymium, are separately enumerated in the table.

Gadolinium and thulium are now for the first time considered to be entitled to rank as elements.

Osmium is altered from 191·7 to 190·8; copper from 63·4 to 63·6; rhodium from 103·5 to 103; and terbium from 159·5 to 160.—*American Druggist.*

DETERMINATION OF WOOD PULP IN PAPER.

UP to the present, two methods for the quantitative determination of the amount of wood pulp in paper have been recommended.

Godefroy exhausts the paper first with cold and then with boiling water, and, lastly, with a nearly boiling solution of tartaric acid in 80 per cent. of alcohol. This done, he treats it again successively with hot and cold water, and then with alcohol and ether. Finally, the paper thus extracted is boiled with a dilute solution of chloride of gold, and the quantity of gold precipitated is weighed. The wood pulp reduces, on an average, 14·285 per cent. of gold. Leo Ehmann made a determination according to this process, and found that it agreed exactly with the results obtained by Godefroy. Elm wood pulp reduces 13·66 per cent. of gold.

The trouble with this method is that there is too much detail connected with it, for the numerous extractions that it requires for the perfect success of this determination take much too long a time.

According to Feeln, on digesting wood pulp with a mixture of 60 per cent. sulphuric acid and 40 per cent. water, it leaves a fixed residuum of 24·5 per cent.; but as this datum is founded upon the results of only two experiments, it requires further confirmation.

Messrs. Benedikt and Bamberger have recently demonstrated that lignine presents a high methylic index and that it would be impossible to determine the amount of wood pulp in paper by means of such index. This latter varies in the different species of wood, and, according to what they have seen in their researches, they conclude that such variations occur within quite wide limits. They found, for example, the figure 19·9 for dry larch wood at 100°, and, on another hand, 30·2 for dry red beech wood. The methylic indices of the woods from which pulp is manufactured are almost the same, viz.:

	Methylic index of the dried wood at 100°.
Pine	22·6
Red pine	22·5
Fir	24·5
Poplar	22·6

In Austria pine and aspen wood are especially employed. Our chemists therefore adopted the figure 22·6 as the basis of their calculation for the papers that they examined.

When there are doubts as to the origin of the wood pulp, the chemical examination may be verified by a microscopic observation, which will permit of easily recognizing the nature of the wood and of finding the proportion of pulp by means of the methylic index of the variety in the presence of which one finds himself.

As well known, we designate by the term "methylic index" the quantity of methyl (expressed in tenths per cent.) that separates under the form of iodide of methyl when the substance is boiled with hydriodic acid.

The determinations were made by means of the Benedikt & Grüssner apparatus, of which, upon Mr. Leo Ehmann's advice, only the part that serves to keep the water of the refrigeratory at about 70° was modified. With the refrigeratory are connected two glass tubes which are twice bent at right angles and extend to the bottom of the vessel. These two tubes are put in communication with the two apertures of a copper apparatus through rubber tubes.

The refrigeratory and the copper apparatus are filled with water and the latter is then heated by a Bunsen burner. As soon as the water begins to boil, the steam drives the air from one of the rubber tubes. Upon compressing the latter for an instant by means of the finger, the other rubber tube becomes filled with water and a regular circulation of the liquid is set up from the refrigeratory, through one of the rubber tubes, toward the copper vessel, and from the other tube to the refrigeratory. The copper generator may be replaced by a balloon provided with a stopper with two apertures, through which pass two glass tubes. One of these, which is straight, ends immediately beneath the cork, while the other runs to the bottom of the balloon, its external part being curved downward.

It is to be remarked that the determination of the methoxyl must be made with the greatest care, for an error of a unit in the methylic index, corresponding to $\frac{1}{10}$ per cent., may cause one of 5 per cent. in the quantity of the wood pulp. Particularly, the determination must be arrested only when the silver solution found above the precipitate is perfectly clear.

In order to reach a greater exactitude, the authors of these researches no longer employ 0·5 gramme solely of the substance (as was the case with essential oils and resins), but 1·5 gramme and 2 grammes, and boil it with 30 cubic centimeters of hydriodic acid (specific gravity 1·7).

It was not till they had terminated these researches that they remarked that it would be advantageous to introduce a little red phosphorus into the balloon in which the boiling is effected, for in this manner no iodine vapors are disengaged and the stopper is much less attacked. The small quantity of sulphur that the paper may contain under the form of sulphate of alumina is without influence. The small quantity of sulphide of silver is easily dissolved when the precipitate is heated with dilute nitric acid.

Instead of using water for filling the absorption apparatus, we may use, besides red phosphorus, a 10 per cent. solution of iodide of calcium.

It has been remarked, on another hand, in experiments made to this effect, that a larger quantity of

sulphur lowers the value of the methylic index by the fact of the formation of mercaptans.

Papers that contain gypsum or sulphate of barium cannot be tested, from the standpoint of wood pulp, by this process.

The specimens of papers that figure below were furnished by Mr. Sembritzki, and were all manufactured from pine wood pulp.

The methylic indices that figure in the table refer to paper dried at 100°.

The concordance of the figures obtained by Messrs. Benedikt & Bamberger with those of Mr. Sembritzki are very satisfactory. The few differences found therein are not worthy of mention.

No. of Paper.	Nature of Sizing.	Percentage of Water.	Percentage of Ashes.	Methylic Index.	Percentage of Wood Pulp.	According to Mr. Sembritzki.	
						Percentage of Wood Pulp.	Other Elements.
2	Unsized.	7·62	0·64	15·46	68·40	70	20 p. 100. Linen rags.
3	Id.	7·53	0·71	13·31	58·89	60	40 " "
4	Id.	7·12	0·90	11·69	51·73	50	50 " "
4	Vegetable size.	6·97	1·80	11.81	52·25	50	50 " "
4	Id.	6·97	1·80	11·74	51·94	50	50 " "
5	Unsized.	6·63	0·94	8·82	39·02	40	60 " "
5	Vegetable.	7·61	1·09	8·73	38·80	40	60 " "
5	Animal.	6·63	2·04	8·77	38·80	40	60 " "
6	Unsized.	6·85	1·02	6·21	27·47	30	70 " "
6	Animal.	6·88	2·15	5·90	26·10	30	70 " "
7	Vegetable.	6·32	2·98	5·19	22·96	20	80 " "
8	Unsized.	6·02	1·17	2·16	9·56	10	90 " "
9	Vegetable.	6·88	12·19	10·55	46·68	43·5	43·5 " "
							13 " China clay.
12	Id.	7·70	1·90	11·95	53·05	50	50 " Cellulose.

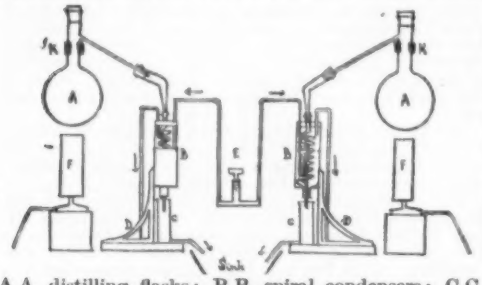
The figure that represents the quantity of wood pulp for paper No. 12 is too high, because the methylic index of the cellulose employed is 0·97, corresponding to 4·29 per cent. of wood pulp. The proportion of wood pulp is to be diminished in this case by 2·15, and we thus reach 50·9 per cent.

The above method may also be very well employed for determining the quantity of lignine that cellulose contains, as well as for following the process of boiling in the manufacture of paper.—*Moniteur Scientifique, from Chemiker Zeitung.*

DETERMINING FREE AND ALBUMINOID AMMONIA.

By G. EMBREY, F.C.S.

IN the beginning of 1891, the citizens of Gloucester received the unwelcome news that the ordinary water supply was exhausted, and it became necessary at very short notice to find some new ones. The river Severn at Gloucester is affected by the tide for about ten or twelve days during the month, and, as some seven or eight towns furnish it with a plentiful supply of sewage, there seemed only two sources: first, the Gloucester



A A, distilling flasks; B B, spiral condensers; C C, Nessler glasses; D D, brackets supporting condensers; E, water tap; F F, Argand burners; K K, clips fastened to shelf.

and Berkeley Ship Canal; and, second, numerous unused wells. Before sanctioning the use of these latter, it was thought by the authorities desirable to have an analysis made of each. Finding the ordinary clumsy arrangement of apparatus unsuitable, and having to make some twelve or more analyses each day, I set to work, with the help of a mechanically inclined assistant, to devise an arrangement which I believe superior to that in common use; the ordinary clumsy retort and condenser takes up too much room, and only one operation can be conveniently managed at one time. What I required was an arrangement so that two analyses could be kept going by one assistant.

My laboratory tables are 8 feet long and 2 feet 3 inches wide, with a small sink with water tap in the middle. On each side of this sink was fitted a distilling flask with spiral condenser, the source of heat being an Argand burner with iron chimney 8 inches high and 2 inches wide. As I had no room for retort stands, I contrived a simple clip screwed on to the shelf at back of bench; this keeps the table free for work. I find the burner can be turned up so that the flame reaches nearly to the top of the chimney, and there is no fear of cracking the flask; the water boiling in a few minutes, the condensation is far better than with the ordinary arrangement of straight Liebig condenser.

I find that by starting one analysis a little before the other, one assistant can perform two determinations in a little over an hour; so that myself and two assistants, working eight hours, could make forty-eight determinations of free and albuminoid ammonia in one day. Though this speed was never reached, we came very near it. It will be noticed that a small convenient adapter connects the flask with the condenser, the corks are covered with tin-foil, this being kept in place by a strong India rubber band. I would call attention to a convenient method of holding the spiral condenser; a small tin cup fastened to an iron bracket, this latter screwed to a wooden base with four screws at the corners, under side. This keeps it from moving about.—*The Analyst.*

COMPOUNDS OF MOLYBDENUM AND OF TUNGSTEN.

PECHARD has examined the yellow coloration produced by the action of hydrogen peroxide upon molybdates and tungstates, and concludes that it is due to higher oxygen compounds of these metals. When potassium trimolybdate is treated with hydrogen peroxide it dissolves, forming an orange-yellow solution which deposits on concentration yellow crystals apparently triclinic, having the composition $K_2 Mo_3 O_{10} (H_2 O)_4$. Heated gently in a vacuum, the crystals lose water and oxygen and leave a residue of acid potassium molybdate. The ammonium salt is similarly prepared. Both salts are decomposed by alkalies with evolution of oxygen. They evolve chlorine when treated with hydrochloric acid and set free iodine from potassium iodide. In the same way, sodium paratungstate boiled for a few minutes with hydrogen peroxide becomes yellow in color and is no longer precipitated by nitric acid. On evaporation the solution deposits white crystals having the composition $Na_2 W_2 O_9 (H_2 O)_2$. The above salts are regarded by the author as establishing the existence of per-molybdic and per-tungstic oxides, $Mo_2 O_7$ and $W_2 O_7$, as well as the corresponding acids, $H_2 Mo_2 O_8$ and $H_2 W_2 O_8$.—*C. R. in J. Chem. Soc.*

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